

FINAL REPORT

PHASE II ENVIRONMENTAL ASSESSMENT DUPONT AUTOMOTIVE PRODUCTS SOUTH SAN FRANCISCO, CALIFORNIA

Prepared for

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March 26, 1999

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**Subject: Phase II Environmental Assessment of the DuPont Automotive Products Site
South San Francisco, California**

Dear Mr. DeStefano:

We are pleased to present our Phase II Environmental Assessment report for the DuPont Automotive Products site located in South San Francisco, California. This study was prepared in accordance with the scope of work in our agreement dated September 24, 1998. Mr Marco Lobascio and Ms April Ann Giangerelli assisted in the preparation of this report.

This report summarizes the findings and our conclusions and recommendations regarding the potential for a significant concern at this site. Please call if you have any questions.

Sincerely,

URS Greiner Woodward Clyde



Albert P. Ridley, C.E.G.
Project Manager

Attachment: Phase II ESA Report

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1.1 INTRODUCTION

This report presents the findings of a Phase II Environmental Site Assessment (ESA) based on the results of soil and groundwater investigation at the former DuPont Automotive Products plant site located at 160 South Linden Street, South San Francisco, California (the site). The purpose of these activities was to evaluate the need and extent (if any) of remedial actions for protection of human health, considering that the site will be redeveloped for commercial/industrial use. We understand that DuPont intends to terminate the current occupancy of the site, which is used for receiving, testing, and shipping of bulk automotive paints, and to sell the property for an alternative commercial use.

The site characterization work reported herein was performed in accordance to the Work Plan submitted to the San Mateo County Health Services Agency (the County) on September 8, 1998, and revised by an Addendum dated September 24, 1998. Ms. Elizabeth Rouan, Hazardous Materials Specialist at the County, approved the Work Plan and Addendum in a letter dated October 1, 1998. Information requested by Ms. Rouan regarding use of glass jars for collecting soil samples for TPH-gasoline and BTEX analyses was provided, as well as moving the location of Boring 17. This report contains a site plan with the requested smaller-sized boring symbols.

We have also submitted the work plan for the Human Health Risk Evaluation and the development of Site Specific Target Levels (SSTLs) on November 25, 1998, as requested by Ms. Rouan in the October 1, 1998 letter. Ms. Rouan approved the approach in a letter dated December 24, 1998. In that letter, Ms. Rouan specified that the target risk should be selected at one-in-a-million, the slope factor for benzene should follow the California EPA recommendations, and the representative site concentrations to be presented in this report. The above requests were addressed in this report by developing the SSTLs based on the specified target risk, applying the California EPA (1994) slope factors for all chemicals that have one, and calculating representative site concentrations based on the 95 percent upper confidence level (UCL) on the mean (USEPA 1992). However, for consistency with the target risk levels applied to the classification of numerous Bay Area sites (e.g., the San Francisco International Airport in San Mateo County), as a reference in support of risk management decisions, we provided in this report an additional set of SSTLs based on one-in-one-hundred-thousands target risk.

Section 1.0 of this report presents the site environmental setting and a summary of past environmental assessment activities. Section 2.0 reports the results of the recent field sampling and laboratory analysis activities that are the basis for the risk-based evaluation of the site. Section 3.0 presents the findings of the site classification process and describes the risk-based evaluation. Conclusions and recommendations are in Section 4.0. References are in Section 5.0.

Appendix A presents the assumptions, the methodology, and the results of the risk-based evaluation of soil and groundwater conditions. This includes the calculations of risk-based SSTLs. Appendix B contains the boring logs. Analytical laboratory reports are in Appendix C. The RWQCB Directive about low-risk sites is provided in Appendix D. Appendix E contains the EDR well search report. Appendix F contains the UCL calculations.

1.2 SITE HISTORY

The DuPont South San Francisco plant (see Figure 1) was an active paint manufacturing operation from 1934 through 1982. Peak production at the plant was in 1955 when employment reached 250 workers. In 1982 operations were reduced and since that time the facility has mainly been used for warehousing paints, and quality control testing of bulk paints that are shipped to the NUMMI plant in Fremont. In 1984 about 6.5 acres of the original 13 acres of the plant were sold. The sale included the warehouse to the south and the office area to the northeast.

A report prepared by DuPont Environmental Services, dated August 30, 1991, describes the results of a subsurface soil investigation that included 11 borings. The locations of the 1991 borings are shown on Figure 2. The Tank Farm and plant buildings are described in that report as being in place but the tanks were empty and only some of the buildings were being used. Since 1991 the Tank Farm has been demolished and all buildings except the Office and Manufacturing Building (Building 21, A, B, C) shown on Figure 2, have also been demolished. The areas north and west of the Manufacturing Building are now leased to tenants for storage of construction equipment.

The August 30, 1991 report also noted the location of a former underground thinner tank at the south property boundary, which was investigated by boring B-7 in 1991, also shown on Figure 2. The location of a former Fork Truck fuel storage tank, at the southeast corner of the former Tank Farm is also shown on the figure. We understand that this tank was also removed prior to 1991. The results of the 1991 study are described in Section 1.4.

1.3 SITE ENVIRONMENTAL SETTING

The site is located on the Bay Plain about 1.5 miles west of the San Francisco Bay (see Figure 1). The site is located at an elevation of about 20 feet above sea level and slopes gently northwestward. A map prepared by the US Geological Survey shows old marshlands, that have been covered with man made fill, begin about 500 feet northeast of the site and extend to the edge of San Francisco Bay. The site is shown on a US Geological Survey map as being underlain by the Quaternary age Colma Formation, which is composed of sand, sandy clay and silty sand. Towards San Francisco Bay younger alluvium and Bay Mud overlie the Colma Formation.

The entire area from the site eastward to San Francisco Bay is developed as industrial and commercial properties. Industrial and commercial properties also extend north, west and south from the site. There are no residential properties in the vicinity of the site.

We performed a computerized search of water wells registered in the Federal or State databases using EDR Inc., provided in Appendix E. Location 1 is the only well that has been identified within the 1-mile search radius. It is well No. 12 at Elm Avenue owned by the City of San Bruno for municipal water service. As shown on the map in Appendix E, this well is located about 3/4 of a mile southwest of the site.

Three locations are identified within a 1-mile radius of the site, as shown on the topographic map in Appendix A. However, two locations (A and B) appear to be the facility addresses of the owners of wells that are not located within the search radius. Location A2 (Olympia Oil Co., 260 Michele Center) is the owner of a well in Ripon, California. Location A3 (California Golf Club,

844 Orange Avenue, South San Francisco) is actually located outside the 1-mile radius northwest of the site. Location A4 appears to be the office location of California Water Service, 230 Miller Avenue, South San Francisco) Location B5 (Sequoia Gardens, 113 Tanforan Avenue, San Bruno) is the listed owner of a public water service for Sequoia Gardens in Santa Rosa, California. Location B6 (2190 Rosewood Drive, San Bruno) is the address of the listed owner for a public water service well for Mobile Home Estates in Santa Rosa, California.

1.4 SUMMARY OF PREVIOUS INVESTIGATIONS

DuPont Environmental Remediation Services (DERS) performed a Limited Environmental Assessment of this site in 1991. Eleven soil borings drilled during that study are shown on Figure 2. The location of the soil borings was selected based upon a review of historical site activities.

Three soil sampling locations were placed in the Tank Farm area. One soil sampling location was placed near the former Thinner Tank. Another soil sampling location was placed near the Resin Tanks. Borings were located near the former Solvent Recovery Area and the Wastewater Treatment Tanks. Borings were drilled near two fuel oil underground tanks, and near two spill containment tanks. The borings were drilled to a maximum depth of 19 feet. Soil samples were collected using a drive sampler with brass liners to collect soil samples at about 2 1/2-foot vertical intervals. Groundwater was encountered between depths of 10 to 15 feet and then rose several feet within the boring. No groundwater sampling or analyses were performed during the 1991 study.

Selected soil samples were analyzed for volatile and semi-volatile organic compounds using EPA Methods 8240 and 8270. Other samples were selected for analysis for metals and for Total Petroleum Hydrocarbons. The highest concentration of volatile organic compounds was detected in soil at a depth of 10 1/2 feet in boring B-9 in the Tank Farm. Toluene was reported at 4,470 mg/kg, m-xylene at 1,270 mg/kg, o+p xylene at 738 mg/kg, and benzene at 3.49 mg/kg in soil from 10 1/2 feet in B-9. The only other significant detection of volatile organic compounds was in soil from 10 feet in boring B-7. Benzene was not detected above the reporting limit of 0.125 mg/kg in B-7. Toluene was reported at 0.647 mg/kg, ethylbenzene was reported at 27.1 mg/kg, m-xylene at 52.8 mg/kg, and o+p-xylenes were reported at 0.748 mg/kg in B-7. Relatively low concentrations of volatile organic compounds were detected in soil from boring B-2, near the Tank Farm. Acetone was reported at 66.5 mg/kg, 2-butanone at 23 mg/kg, toluene at 0.437 mg/kg, and hexanone at 3.1 mg/kg in B-2 at 10 feet.

The concentration of toluene in boring B-9 at 4,470 mg/kg exceeded the USEPA PRG of 520 mg/kg for soil at an industrial site. Xylene at 1,270 mg/kg in boring B-9 also exceeded the USEPA industrial PRG for soil, which is 210 mg/kg. Benzene at 3.49 mg/kg in soil from B-9 also exceeded the USEPA industrial PRG of 1.36 mg/kg.

Methylene chloride was reported in all of the 23 soil samples at concentrations ranging from 0.3 mg/kg to 0.7 mg/kg. Methylene chloride is a common laboratory contaminant and the laboratory is likely the source of these reported detections. Di-n-butylphthalate was reported in most of the soil samples at concentrations ranging from 1.02 mg/kg to 3.87 mg/kg.

The laboratory reported no detection of TPH above the reporting limit in soil samples from borings B-5 and B-11 near the former Fuel Oil USTs. Soil samples from borings B-4 and B-6

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Introduction

were analyzed for metals using EPA Method 6010. The laboratory reported concentrations of these metals in the soil samples from borings B-4 and B-6 were below the USEPA Industrial PRGs.

SECTION TWO

Summary of 1998 Field Sampling and Laboratory Analyses

2.1 SUMMARY OF 1998 SITE INVESTIGATION ACTIVITIES

This section describes the sampling activities performed at the site between October 8 and October 12, 1998. Figure 2 shows the soil and groundwater sampling locations. A total of 11 soil borings were drilled to collect soil and groundwater samples at various depths. The soil borings were drilled using a Geoprobe rig. In addition, shallow soil samples were collected at 5 other locations.

The sampling locations were selected to provide information about the distribution of chemicals in the site subsurface for the risk-based evaluation. The results of previous investigations were considered in selecting the locations, as was described in the work plan dated September 8, 1998 (Woodward-Clyde, 1998b). Soil and groundwater samples were collected where potential contaminants may have been stored or used at the site (Figure 2). These areas include the Pigment Storehouse, Resin Tanks, Fuel Oil USTs, the former underground fuel tank removed in 1987, the former Thinner UST, and the Tank Farm. Samples were also collected at the southeast and northeast corner of the site to evaluate soil and groundwater conditions at the perimeter of the site. Four borings (12, 13, 14 and 15) were located to explore the extent of the previously detected toluene and xylenes in soil from the 1991 study by Du Pont Environmental Remediation Services (DERS, 1991). The five shallow soil samples (S1, S2, S3, S4 and S5) were collected from the ballast rock beneath the three rail spur tracks entering the site. Experience indicates that railroad ballast rock materials may contain elevated concentrations of metals and petroleum compounds. Borings 18, 19, 20, 21 and 22 were located at the perimeters of the site. Soil and groundwater analyses for each sample were chosen based on the type(s) of potential contamination expected at the locations.

Samples from each location were labeled with a series of letters and numbers to identify the project site, i.e., South San Francisco (SSF), the matrix type, i.e., soil (S) or groundwater (G), the location (SB-12 through SB-22 for the borings, and S1 through S5 for surface soil sampling locations), and the sample depth (0-1, 3-4, 8-9). Soil samples were collected in each of the 11 borings at a depth of approximately 0 to 3 feet, 3 to 5 feet, and 8 to 11 feet. The 5 shallow samples were collected with hand tools when feasible at a depth of 0- to 12-inches. A total of 47 soil samples were collected, including 10 soil samples taken at 8 feet with the EnCore Sampler.

At each of the 11 boring locations, groundwater samples were collected at a depth of 16 to 20 feet. A total of 11 groundwater grab samples were collected using a clean Teflon tube and peristaltic pump.

During drilling, an Organic Vapor Meter (OVM) was used to perform field measurements for the presence of organic vapors from soil collected from the borings. Soil from the drive sampler was placed in a plastic bag, sealed and allowed to sit in the sun for about 5-10 minutes. The OVM was used to measure the presence of vapors inside the plastic bag, and these measurements were recorded on the log of each boring.

A site specific Health and Safety Plan was developed for and followed by personnel working on-site (Woodward-Clyde, 1998). Sampling locations were carefully positioned away from utilities. Utility clearance was established with the assistance of Underground Services Alert (USA) and Cruz Brothers Locators, Inc. of Milpitas, California.

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Summary of 1998 Field Sampling and Laboratory Analyses

Fast-Tek Engineering Support Services of Point Richmond, California was retained as the drilling subcontractor. Borings were advanced using a truck-mounted pneumatically powered Geoprobe. Soil samples were collected in 2-inch diameter sample tubes within the drive sampler, and then placed into 125 mL and 500 mL clean glass jars provided by the laboratory. Packing the soil into the jars minimized headspace in the jars. The EnCore Sampler was used to collect soil samples intended for VOCs analysis using the USEPA Method 8260. The EPA has approved use of the EnCore Sampler under SW-846 III, as an alternative sampling technique for short term sample storage followed by laboratory methanol preservation or other appropriate sample preparation (New Technologies, 1997). The EnCore Sampler has a smaller sampling tube in a T handle that can be cored into the end of the 2-inch diameter sample tubes. Use of the EnCore Sampler eliminates the need for methanol or sodium bisulfate preservation in the field. The jars were sealed with Teflon-lined jar caps, and labeled with the date, time, and sample name. Samples were then placed into a cooler. Soil samples were shipped daily by FedEx Priority Overnight to the laboratory under chain-of-custody procedures.

Groundwater samples were collected in 40-mL bottles preserved with HCl, 1000-mL bottles preserved with HCl, 1000-mL bottles preserved with $\text{Na}_2\text{S}_2\text{O}_3$, and 500-mL bottles preserved with HNO_3 . Water samples intended for Title 22 total metal analysis were filtered using a 0.45 micron Posi filter before being preserved with HNO_3 . The bottles were sealed and labeled with the date, time, and sample name. Samples were then placed into a cooler. Water samples were shipped daily by FedEx Priority Overnight to the laboratory under chain-of-custody procedures.

Three of the 5 shallow soil samples collected required use of the Geoprobe rig because the rail spurs had been paved over with cement. At the shallow sample location SSF-S-S3-0-1, it was necessary to drill to five feet before collecting a sample since the tracks used to be 4 feet lower than the current ground surface. At soil boring location SSF-S-SB-20 behind the manufacturing building, it was necessary to drill through 8 feet of concrete slabs before a soil sample could be collected.

A temporary PVC well casing was placed in three of the boreholes to allow for measurement of groundwater levels. The relative elevation of the top of the well casings was surveyed so that a general groundwater gradient could be estimated for the site. Each boring was backfilled with cement grout after groundwater sampling was completed.

Boring logs were compiled for each sampling location. The logs contain information pertaining to the USCS Soil Classification system, material description, OVM readings, start and end times, the date, first encounter with groundwater, and the total depth drilled. The logs also provide information on the names of the drilling company and the sampler, drilling method, drill rig type, drill bit size, diameter of the hole, type of grout, and the sampler type. The boring logs can be found in Appendix B of this report.

2.2 ANALYTICAL RESULTS

This section describes the laboratory analyses performed on the samples collected at the site between October 8 and October 12, 1998. Soil and groundwater samples were analyzed by Lancaster Laboratories of Lancaster, Pennsylvania for BTEX and TPH- gasoline and TPH-diesel by EPA Method 8015/8020, VOCs by EPA Method 8260, SVOCs by EPA Method 8270, PCBs

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Summary of 1998 Field Sampling and Laboratory Analyses

by EPA Method 8082 and Title 22 metals by EPA Method 6010. Samples taken at depths of 0 to 3-feet and 3- to 5-feet were to be held by the laboratory until a decision was made to analyze these samples to fill in any data gaps. Quanterra of West Sacramento, California was retained to analyze the soil samples for Title 22 metals by EPA Method 6010.

In the vicinity of the Tank Farm, all soil samples from Borings 12, 13, 14 and 15 (Figure 2) were analyzed for TPH-gasoline, TPH-diesel, BTEX, and SVOCs, based on the previous environmental investigation (DERS, 1991) detection in soil of a relatively high concentration of BTEX, in particular, 3 mg/kg benzene. Samples collected in the Tank Farm area at 8- to 11-feet were also analyzed for VOCs. The water table was believed to be at 6 to 9 feet (DERS, 1991). Groundwater in the Tank Farm area was analyzed for TPH-gasoline, TPH-diesel, BTEX, SVOCs and VOCs. The soil samples taken at 0 to 3-feet from Borings 12 and 15 were analyzed for Title 22 metals since they are located on a former rail spur and experience indicates that railroad ballast rock materials may contain elevated concentrations of metals. For the same reason, the groundwater samples from Borings 12 and 15 were also analyzed for Title 22 metals.

The soil samples collected at Borings 17, 18 and 22 were analyzed for TPH-gasoline, TPH-diesel, BTEX and SVOCs. Soil samples collected at 8- to 11-feet in each of the locations were also analyzed for VOCs. Soil samples collected at 0 to 3-feet in Borings 16, 17, 18 and 22 were analyzed for Title 22 metals, and the water samples collected from these borings were analyzed for TPH-gasoline, TPH-diesel, BTEX, SVOCs, VOCs, and Title 22 metals. The water samples collected at Borings 20 and 21 were analyzed for each of these chemicals except for TPH-diesel and Title 22 metals.

Boring 17 was located downgradient of the former fuel UST removed in 1987. Borings 18 and 22 were located at the eastern boundary and the northeast corner, respectively, of the site in order to evaluate the soil and groundwater conditions at the perimeter of the site, and to help delineate potential migration of chemicals in the groundwater.

Boring 16 was located near the former Resin Storage Tanks, and Boring 21 was located near the Pigment Storehouse. Resins and pigments may contain SVOCs, therefore the soil samples taken at 0 to 3-feet and 3- to 5-feet at these two locations were analyzed for SVOCs. The soil samples collected at 8- to 11-feet were analyzed for SVOCs and VOCs. The soil samples collected at 8- to 11-feet in Boring 16 were also analyzed for TPH-gasoline, TPH-diesel and BTEX.

Borings 19 and 20 were located at the southern perimeter of the site. Boring 20 was located downgradient of the former Thinner UST, and therefore, soil samples were analyzed for SVOCs. Boring 19 was located near a transformer at the southeastern corner of the site, and the soil sample at 0 to 3-feet and the groundwater sample were analyzed for PCBs. The soil collected at 8- to 11-feet sample from Boring 19 was analyzed for TPH-gasoline, TPH-diesel and BTEX.

The shallow soil samples, S1, S2, S3, S4 and S5, were collected from the ballast rock beneath the three rail spur tracks entering the site. All of the soil samples were analyzed for Title 22 metals, and the samples near the Tank Farm, S3, S4 and S5, were also analyzed for TPH-diesel.

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Summary of 1998 Field Sampling and Laboratory Analyses

Soil Analytical Results

Table 1 presents the results of the laboratory analyses performed on the soil samples from the site. The table is organized by analysis type and sample number, and with the exception of benzene, only those VOCs and SVOCs detected in at least one sample are listed on the table. Results above the detection limit appear in bold type. A dash in the table indicates that the sample was not analyzed for the particular analyte. The row "Depth to Water" indicates the depth when water was first encountered during drilling.

Using EPA Method 8015/8020, toluene, ethylbenzene, xylene, TPH-gasoline and TPH-diesel were detected in over half of the soil samples. Toluene was detected in 17 out of 24 soil samples, and concentrations ranged from 0.006 mg/kg to 180 mg/kg, with the highest concentration in Boring 12 at 3- to 5-feet. Ethylbenzene was detected in 16 out of 24 soil samples, and concentrations ranged from 0.006 mg/kg to 92 mg/kg in Boring 13 at 3- to 5-feet. Xylenes were also detected in 16 of the 24 samples, and concentrations ranged from 0.024 mg/kg to 490 mg/kg in Boring 13 at 3- to 5-feet. TPH-diesel was detected in 15 of 27 soil samples, and concentrations ranged from 25 mg/kg to 2,000 mg/kg in shallow soil sample S3. TPH-gasoline was detected in 13 of 24 soil samples, and the concentrations ranged from 2 mg/kg to 870 mg/kg in Boring 14 at 8- to 11-feet.

Using EPA Method 8260, with the EnCore Sampler, toluene, ethylbenzene, xylene, acetone and 2-butanone were detected in less than half of the 10 soil samples analyzed. Toluene, detected in 4 soil samples, ranged from 87 mg/kg to 200 mg/kg in Boring 15 at 8- to 11-feet. Ethylbenzene was detected in 4 samples, with concentrations ranging from 16 mg/kg to 50 mg/kg in Boring 13 at 8- to 11-feet. Xylene was also detected in 4 samples, and the range was 66 mg/kg to 260 mg/kg in Boring 13 at 8- to 11-feet. Acetone was detected in 2 of the 10 soil samples, with the highest concentration being 73 mg/kg in Boring 13 at 8- to 11-feet. 2-Butanone was detected only once in Boring 13 at 8- to 11-feet at 3.3 mg/kg.

Samples taken at a depth of 8- to 11-feet were analyzed for BTEX using both EPA Method 8015/8020 and EPA Method 8260 by the EnCore Sampler method. Toluene, xylene and ethylbenzene were detected in the samples from Borings 12, 13, 14 and 15 using both methods. The results of EPA Method 8260 using the EnCore Sampler proved to be the more accurate and conservative of the two methods at higher concentrations. Therefore, in Table 1 the results for BTEX using EPA Method 8260 for samples taken at 8- to 11-feet in Borings 12, 13, 14 and 15 were used to characterize the soil in the area of the former Tank Farm, instead of the results from EPA Method 8015/8020. However, EPA Method 8015/8020 seems to be more accurate and conservative at detecting BTEX at lower concentrations since the detection limit is lower than that of EPA Method 8260. Therefore, the results of the EPA Method 8015/8020 analyses for BTEX were used to estimate the concentrations of these analytes in the soil samples.

Using EPA Method 8270, SVOCs were detected in the area of the Tank Farm. The majority of the detections occurred in Boring 12 at 3- to 5-feet, but some detections occurred in Borings 13, 14 and 15. Benzo(a)pyrene, di-n-butylphthalate, and naphthalene were detected in soil at maximum concentrations of 0.48 mg/kg, 200 mg/kg, and 5.4 mg/kg, respectively.

All of the Title 22 metals with the exception of antimony, molybdenum, selenium, silver and thallium were detected in the soil samples from the site. The metals were found to be distributed

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Summary of 1998 Field Sampling and Laboratory Analyses

throughout the surface soils of the site, in particular at S1 where arsenic had a maximum detection of 194 mg/kg and lead had a maximum detection of 4,200 mg/kg

Water Analytical Results

Table 2 presents the laboratory analyses results for the groundwater samples from the site. The table is organized by analysis type and sample number, and only those VOCs and SVOCs detected in at least one sample are listed on the table. Results above the detection limit are presented in bold type, and a dash indicates that the sample was not analyzed for the particular analyte. The row "Depth to Water" indicates the depth water was first encountered during drilling.

EPA Method 8015/8020 was used to analyze for BTEX, TPH-diesel and TPH-gasoline in groundwater. A total of 10 water samples were analyzed for BTEX. Benzene was detected in 5 water samples with concentrations ranging from 0.001 mg/l to 0.4 mg/l in Boring 12 (see Figure 2). As shown in Figure 3, toluene was detected in 5 water samples, and concentrations ranged from 0.004 mg/l to 120 mg/l in Boring 12. Ethylbenzene was detected in 7 water samples, and concentrations ranged from 0.001 mg/l to 8.9 mg/l in Boring 15. Total xylenes were detected in 6 water samples with concentrations ranging from 0.009 mg/l to 39 mg/l in Boring 15. Seven water samples were analyzed for TPH-diesel, and all the samples had detections ranging from 0.75 mg/l to 9.1 mg/l in Boring 12. Seven out of 10 water samples detected TPH-gasoline, and concentrations ranged from 0.22 mg/l to 380 mg/l in Boring 12.

EPA Method 8260 was used to analyze for VOCs in the groundwater samples. BTEX, acetone, 2-butanone, 1,2-dichloroethane, and 4-methyl-2-pentanone were found in the 10 water samples analyzed. Benzene was detected only in Boring 20 at a concentration of 0.022 mg/l. Toluene was detected in 4 samples, and concentrations ranged from 2 mg/l to 150 mg/l in Boring 12. Ethylbenzene was detected in 5 samples ranging in concentration from 0.068 mg/l to 5.8 mg/l in Boring 12. Xylene was detected in 6 water samples, and the concentration range was from 0.007 mg/l to 24 mg/l in Boring 12. Acetone was found in 5 water samples, ranging in concentration from 0.077 mg/l to 530 mg/l in Boring 12. 2-Butanone was detected in 3 water samples, and the highest detection was 22 mg/l in the water sample from Boring 12. 1,2-Dichloroethane was detected in only one sample, Boring 21, at 0.016 mg/l. 4-Methyl-2-pentanone was detected in Boring 12 and 13, at concentrations of 44 mg/l and 0.23 mg/l, respectively.

Groundwater samples were analyzed for BTEX using both EPA Method 8015/8020 and EPA Method 8260. The results of EPA Method 8015/8020 were used to characterize BTEX in groundwater since the results of both methods were very similar. However, the results for toluene, ethylbenzene and xylenes using EPA Method 8260 in the water sample from Boring 12 were used instead of the results from EPA Method 8015/8020 since they exceeded maximum contaminant levels (MCLs). This was also true for benzene in the water sample from Boring 20.

The SVOCs detected in the water samples from the site include the following: diethylphthalate, 2,4-dimethylphenol, di-n-butylphthalate, 2-methylnaphthalene, 2-methylphenol, 4-methylphenol, naphthalene and phenol. Naphthalene and phenol were detected at maximum concentrations of 0.79 mg/kg and 0.02 mg/kg in Borings 20 and 12, respectively.

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Summary of 1998 Field Sampling and Laboratory Analyses

Eight of the Title 22 metals were detected in the 6 groundwater samples, and these include the following metals: arsenic, barium, boron, chromium, copper, nickel, vanadium and zinc. Arsenic was found in 5 water samples at a concentration ranging from 0.013 mg/l to 0.113 mg/l in Boring 22.

2.3 QUALITY ASSURANCE/ QUALITY CONTROL REVIEW

A QA/QC review was performed on the analytical results for the soil and groundwater samples collected on October 8 to 12, 1998. A total of 47 soil samples and 11 groundwater samples were collected, in addition to a matrix spike and a matrix spike duplicate for soil. The QA/QC review evaluated the following items:

- Holding time review to check for exceedences in prescribed extraction and analysis holding times
- Blank review (Trip blank, Laboratory method blank and Equipment blanks) to evaluate blank results for detections of target analytes, as a check for potential sample contamination.
- Matrix Spike (MS), Matrix Spike Duplicate (MSD), Laboratory Control Sample (LCS), Laboratory Control Sample Duplicate (LCSD) to review spike recoveries and spike duplicate relative percent differences (RPDs) to evaluate analytical accuracy and precision.

The criteria for the evaluation were based on the USEPA's National Functional Guidelines for Organic and Inorganic Data Review (USEPA 1994).

Holding Time Review

The extraction and analysis holding time for each sample was reviewed for exceeded method holding times. The following samples were analyzed within the guidance specified holding time, but were received by the laboratory at 8°C, exceeding the recommended temperature of 4±2°C: SSF-S-SB-12-8-9, SSF-S-SB-13-8-9, SSF-S-SB-14-8-9, SSF-S-SB-16-8-9, SSF-S-SB-17-8-9, SSF-S-SB-18-8-9, SSF-G-SB-13, SSF-G-SB-14.

The field geologist stated the temperature bottle was left in the styrofoam holder in the cooler. The bottle was not in the ice in the cooler, and was not an accurate reading of the cooler temperature. The following samples were analyzed using EPA Method 8260 outside the guidance specified holding time: SSF-S-SB-15-8-9, SSF-S-SB-20-8-9, SSF-S-SB-21-8-9, SSF-S-SB-22-8-9.

Blank Review

Equipment, trip and laboratory method blank results were reviewed for detections of target analytes. Trip and equipment blanks are analyzed in the same manner as field samples. The trip blank is prepared by the laboratory and is not opened in the field, and it is used to assess the potential for sample contamination due to sample storage and analysis within the laboratory. The equipment blank is prepared in the field using laboratory supplied "blank" water, and is used to assess the potential for sample contamination as a result of sample collection, handling, storage and analysis. Laboratory method blanks consist of reagents specific to each individual analytical

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method that were prepared and analyzed by the laboratory in the same manner as the regular samples, therefore enabling the measurement of contamination within the laboratory.

There were no target analytes detected in the trip or laboratory method blanks. Zinc was detected in Equipment blank #4 at 0.337 mg/l. Zinc was detected in three of the project groundwater samples, but at concentrations not exceeding 0.041 mg/l.

With the exception of the elevated reporting limit for zinc in Equipment blank #4 as discussed above, laboratory and sample collection procedures were considered acceptable, and not a potential source of sample contamination.

MS/MSD, LCS/LCSD and Replicate Review

Sample spike and sample spike duplicate samples are prepared within the laboratory by dividing a control sample into two aliquots, then spiking each with identical concentrations of specific analytes. The spike samples are then analyzed separately and the results are compared to determine the effects of the sample matrix on the accuracy and precision of the analytes. Accuracy is assessed by the calculation of the *relative percent recovery (RPR)* and precision is assessed by the *relative percent difference (RPD)*. US EPA considers an RPR between 25% to 130%, and an RPD value less than 20% to be acceptable (USEPA, 1994).

Laboratory control sample (LCS) recoveries, matrix spike (MS) recoveries and spike duplicate relative percent differences (RPDs) were reviewed as a check for analytical accuracy and precision. The LCS is a known sample made by the laboratory for a specific analyte that is analyzed by the laboratory, and the percent recovery is compared to the original added amount of the analyte. The MS is created by the laboratory by taking a control sample of soil/water and adding a specific analyte, analyzing it, and then comparing the percent recovery to the original analysis of the soil/water sample. The replicate sample is a means by which the laboratory can internally evaluate its precision and accuracy, by taking a replicate of a field sample, and then comparing the RPR and RPD. Recoveries and RPDs for the different analytical methods can be found in the following table.

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TABLE 2.2. QUALITY ASSURANCE/QUALITY CONTROL REVIEW

Compound	LCS Recovery (%)	LCSD Recovery (%)	RPD for LCSD Recovery (%)	MS Recovery (%)	MSD Recovery (%)	RPD for MSD Recovery (%)
EPA Method 6010B						
Metals in soil	84-96.7			37-123	29-106	0-23
Metals in water	98-105	98-115	0-14	90-107	89-106	0-2
Antimony in water	100-104	102-108	1-3	103-107	104-106	0-1
EPA Method 7470A						
Mercury in soil	100			99	98	0.97
Mercury in water	99-100	103-115	4-14	57-90	63-89	1-8
EPA Method 7060						
Arsenic in soil	92			71	64	5.7
EPA Method 7421						
Lead in soil	106			116	96	6.4
EPA Method 7740						
Selenium in soil	104			64	60	6.6
EPA Method 7841						
Thallium in soil	110			112	113	1.4
EPA Method 8015/8020						
Soil	103-117	99-112	2-4	91-103	95-105	0-5
Water	75-116	77-111	0-4	97-117	95-130	2-28
EPA Method 8082						
Soil	75-81	76-81	0-1	69-77	69-77	0
Water	72-77	74-80	2-4	66-81	65-79	0-3
EPA Method 8260						
Soil	73-133	98-129	0-12	56-108	65-113	0-9
Water	68-137	72-124	0-15	72-123	55-137	0-20
EPA Method 8270						
Soil	45-111	45-105	0-29	8-98	10-118	0-166
Water	26-112	24-112	0-16	43-114	39-118	0-25

The LCS and MS recoveries for Method 6010, except for three metals, were within laboratory control limits and indicate acceptable analytical accuracy and precision. Batch matrix spike and

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Summary of 1998 Field Sampling and Laboratory Analyses

spike duplicate recoveries for antimony, chromium and manganese were outside control limits. however lab control spike recoveries met acceptable criteria. Method 7060 for arsenic and Method 7740 for selenium both had matrix spike duplicates that had recovery outside the control limits, however the recoveries were confirmed by re-analysis indicating matrix interferences. The lab control spike recoveries in both analyses were in control

All RPRs and RPDs for EPA Method 8015/8020 and EPA Method 8082 were within laboratory control limits and indicate acceptable analytical accuracy and precision.

The MS and MSD recoveries for EPA Method 8260 for toluene in soil sample SSF-S-SB-12-8-9 were out of the laboratory control limits of 56% to 150%. The MS RPR for toluene in this sample was 193%, and the MSD RPR was 223%. The LCS and LCSD recoveries for chlorobenzene and styrene were both outside of the laboratory control limits. The RPR for chlorobenzene was 118%, exceeding the range of 69% to 117%, and the RPR for styrene was 120%, exceeding the range of 75% to 116%. The LCSD RPD for chloroethane was 37%, which exceeded the maximum RPD of 30%.

The high MS and MSD recoveries for toluene in soil sample SSF-S-SB-12-8-9 caused the data point to be disqualified, and should be considered only an estimate of the concentration of toluene in that sample. The LCS recoveries for chlorobenzene, styrene and chloroethane do not effect the field data since none of these analytes were detected in soil or groundwater.

Numerous analytes in both soil and groundwater LCS/LCSD and MS/MSD samples for EPA Method 8270 exceeded the laboratory control limits, but this does not affect the field data set since these analytes were not detected in any of the field samples.

Laboratory replicates were prepared and analyzed. All replicate relative percent differences were within the precision acceptance range.

Overall QA/QC Assessment

The results of the QA/QC analysis for soil and water indicates acceptable levels of analytical precision and accuracy.

SECTION THREE

Low-Risk Site Classification

This section presents the findings of the site classification process and describes the results of the risk-based evaluation for the site. The site classification was performed according to the requirements of the RWQCB (1996) directive that is intended for the regulatory and technical audience to expand on the interim guidance provided in the December 8, 1995 letter from Walt Pettit, Executive Director of the State Water Resources Control Board. The interim guidance addresses the findings of a report entitled "Recommendations to Improve the Cleanup Process for California's Leaking Underground Fuel Tanks (LUFTs)" issued by the Lawrence Livermore National Laboratory (LLNL). The LLNL (1995) report indicates that natural attenuation of petroleum hydrocarbons is an important factor in stabilizing plumes and may be the only remedial activity necessary in the absence of free product. The LLNL report found that petroleum plumes tend to stabilize close to the source, generally occur in shallow groundwater and rarely impact drinking water wells in the state. Based on this information, Mr. Pettit's letter urges cleanup agencies to proceed aggressively to close low risk soil only cases and discontinue active remediation of low risk groundwater cases.

We realize that the site is not a fuel-only site due to the presence of non fuel-related chemicals such as chlorinated compounds. However, the criteria developed by the Agencies for fuel sites can be applied to the site based on the following rationale.

The fate and transport properties and toxicity of the chemicals of concern (COCs) at fuel sites (BTEX, PNAs, lead and additives) are comparable to the properties of the COCs at the site, namely 1,2-DCA and other VOCs, BTEX, PNAs, and metals, some of which may be fuel-related. For instance, benzene and 1,2-DCA are VOCs that manifest similar mobility and volatility due to relatively low soil adsorption coefficient (K_{oc} less than 100 cc/g), moderate Henry's constant (H' of 0.22 and 0.04, respectively), and solubility in the thousands of mg/l (USEPA 1998).

Benzene and 1,2-DCA have also similar carcinogenic potential, with slope factors of 0.11 and 0.07 [$1/(mg/kg\text{-}day)$], respectively (Cal/EPA 1994). Most important, published environmental degradation half-life (Howard 1991) ranges from several weeks to a maximum of two years for benzene and a one year maximum for 1,2-DCA. Combining mobility, persistence, and toxicity properties, 1,2-DCA in the subsurface is about as potentially hazardous as benzene.

The other COCs at the site are semivolatile compounds and metals with relatively low mobility and volatility, similar to fuel-related PNAs such as benzo(a)pyrene (BaP) and naphthalene, and metals such as lead. Combining mobility, persistence, and toxicity properties, it is concluded that, from the standpoint of contaminant migration and potential health impact, the low risk classification criteria are applicable to a broad range of non-fuel related chemicals. In particular, these criteria apply to the environmental setting and COCs at this site.

According to the RWQCB (1996), the low-risk groundwater case must satisfy the following six conditions:

1. Active Source Removal: The leak has been stopped and ongoing sources, including free product, have been removed or remediated
2. Adequate Site Characterization: The site has been adequately characterized
3. Verification of Plume Stability: The dissolved hydrocarbon plume is not migrating.

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4. No Impact on Water Resources: No water wells, deeper drinking water aquifers, surface water, or other sensitive receptors are likely to be impacted.
5. No Impact on Human Health: The site presents no significant risk to human health.
6. No Impact on Ecological Receptors: The site presents no significant risk to the environment.

The full RWQCB description of these conditions is provided in Appendix D. Conditions 5 and 6 above require a risk-based evaluation that includes the development of Site-Specific Target Levels (SSLs) as presented in Section 3.7.

3.1 CONDITION ONE: ACTIVE SOURCE REMOVAL

This condition requires that the leak(s) to have been stopped and ongoing sources, including free product, have been removed or remediated. Based on the field investigation results, the following areas represent potentially active sources of contamination that may warrant remedial action:

- The Former Tank Farm Area, where relatively high concentrations of VOCs and SVOCs were detected in Borings 12 and 15 (see Figure 4). The likely sources of chemicals released in this area are the former aboveground tanks and piping at the Tank Farm, or the former underground fuel tank and piping at the southwest corner of the Tank Farm (Forklift Truck Tank), and the "Former Thinner Underground Tank" and piping (Figure 2). Since the aboveground and underground tanks and piping have already been removed, these structures do not represent an ongoing source of VOCs and SVOCs. However, the concentration of xylenes detected in soil are of the same order of magnitude of the saturated soil concentration estimated using the ASTM (1995) equations (about 500 mg/kg). This indicates that free product may be present in soil in those areas.
- The areas near sampling locations S1 and Boring 22 where relatively high concentrations (with respect to PRGs) of arsenic and lead were detected in surficial soil (see Figure 4).
- Since detected chemical concentrations in groundwater are significantly lower than solubility limits, we conclude that the shallow groundwater does not represent an active chemical source (see Figures 5 and 6).

The potential impact on human health and groundwater quality of the above-described areas and the need for removal action are addressed below as part of the discussion of the other conditions. The source areas need to be delineated in more detail before making remedial action decisions. It is our opinion that Condition One may be satisfied by performing remedial action based on the criteria discussed below.

3.2 CONDITION TWO: ADEQUATE SITE CHARACTERIZATION

This condition requires adequate characterization of the site. The site subsurface has been characterized by drilling eleven soil borings and collecting grab groundwater samples. Soil and groundwater samples were analyzed for metals, VOCs, SVOCs, Total Petroleum Hydrocarbons as gasoline and diesel, and PCBs in accordance with the Work Plan approved by the County. The outcome of these activities was the identification of the potential active source areas.

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Low-Risk Site Classification

Additional characterization is needed to delineate the extent of VOCs in soil at the former Tank Farm Area, and of arsenic and lead in surficial soil near locations S1 and Boring 22 (see Figure 4). Delineation of groundwater conditions needs to be performed for VOCs and SVOCs downgradient of the Former Tank Farm area, and for arsenic downgradient of Boring 22 (see Figures 5 and 6).

Relatively low concentrations of VOCs and SVOCs in groundwater were detected at Boring 20, near the former Thinner Underground Tank. These VOCs and SVOCs are of limited extent as they are not found in groundwater from Boring 18 located downgradient of Boring 20. Therefore, no additional delineation is warranted at this location.

In our opinion, Condition Two may be satisfied once the additional delineation activities are performed

3.3 CONDITION THREE: VERIFICATION OF PLUME STABILITY

This condition requires that the dissolved hydrocarbon plume is not migrating. Groundwater conditions have been characterized by analysis of grab groundwater samples from 11 borings on the site, and measurement of the groundwater elevations was performed in order to calculate the groundwater gradient and flow direction. The extent of the VOC groundwater plume has been established on the site, and is limited to a portion of the former Tank Farm area (see Figure 6).

It is our opinion that Condition Three may be satisfied after recommendations for characterization of the downgradient extent of the groundwater plume at the former Tank Farm area are implemented as described below under the Recommendations section

3.4 CONDITION FOUR: NO IMPACT ON WATER RESOURCES

Condition Four requires that no water wells, drinking water aquifers, surface water, or other sensitive receptors are likely to be impacted

Based upon a search of registered water wells performed by EDR, Inc., no water wells are known to exist at the site or in its vicinity. The nearest surface water body is the channeled Colma Creek located approximately 3,500 feet to the north. The nearest open water is a slough located approximately 2,000 feet to the east, which connects to the San Francisco Bay 1.5 miles to the east (see Figure 1).

The 1995 Water Quality Control Plan for the San Francisco Bay Basin identifies this site as within the South Bay Basin, San Mateo Plain sub-basin. The beneficial uses of groundwater within this sub-basin are: existing uses as municipal and domestic water supply, industrial process water supply, industrial service water supply, and potential agricultural water supply. Based upon the distance to the nearest stream or surface water body, we believe that there is no potential for the site contaminants to impact surface water bodies. The distance to existing wells (at least 3/4 mile to the south) indicates that the potential for impacting existing wells is insignificant. We conclude that when downgradient characterization of the groundwater plume is completed as recommended below Condition Four may be satisfied.

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3.5 CONDITION FIVE: NO IMPACT ON HUMAN HEALTH

Condition five requires that the site not pose a significant risk to human health. This condition was met by performing a risk-based evaluation following the ASTM RBCA guidance (ASTM 1995). As part of the evaluation, a set of risk-based site-specific target levels (SSTLs) was developed. The SSTLs represent soil and shallow groundwater concentrations protective of human health at the site. Comparison of site concentrations to the SSTLs indicate that chemicals in the site subsurface do not pose a significant human health risk (see Tables 10 and 11), provided that the areas exceeding SSTLs are remediated (see Figures 4, 5, and 6). These areas are associated with the source areas described in Section 3.1. The source areas will be further delineated and characterized as described in Section 3.2. The human health risk evaluation is described in detail in Appendix A. Based on the above considerations, we conclude that Condition Five may be satisfied once Conditions One and Two are satisfied.

3.6 CONDITION SIX: NO IMPACT ON ECOLOGICAL RECEPTORS

This last condition requires that the site does not pose a significant risk to the environment. This condition is met by the absence of ecological receptors in the area as well as the lack of potential for off-site transport of chemicals. The site is located in a highly industrialized and urbanized area and the site and its surroundings consist primarily of paved surfaces. As shown on Figure 1, there are no sensitive environments or habitats that could support flora or fauna at the site or in its vicinity to a ¼ mile radius (e.g., wetlands, streams, creeks, parks, wilderness areas, and open spaces). The absence of ecological receptors and suitable habitat renders all potential ecological exposure pathways onsite and in the vicinity incomplete. In addition, once the groundwater plume has stabilized and the concentrations are decreasing or asymptotic (as discussed in Section 3.3), the potential for off-site transport of chemicals to distant off-site receptors such as the San Francisco Bay will be reduced. Based on the above considerations, we conclude that Condition Six may be satisfied when Condition Three is satisfied.

SECTION FOUR

Conclusions and Recommendations

The **CONCLUSIONS** of this study are the following:

- The conditions of the RWQCB (1996) guidelines for the classification of the site as a low-risk groundwater case will be satisfied once the chemical sources are delineated and removed, and plume stability is verified.
- Based on the results of risk-based evaluations, when the above-described soil sources are remediated, we evaluate that site soil and shallow groundwater do not warrant further consideration related to protection of human health.

The **RECOMMENDATIONS** of this study are the following:

- Delineate lateral and vertical extent of the sources of chemicals in soil. Perform appropriate soil remediation activities for the source areas.
- Collect grab groundwater samples downgradient of the site to evaluate the extent of the plume. At a minimum, two monitoring wells should be installed along the plume centerline. One well will be placed near the sources, the other at the front edge of the plume. A third well should be located in an upgradient location. These wells will be monitored for several quarters, until plume stability is demonstrated.
- Once the sources are delineated and remediated, and plume stability is verified, we recommend that the County of San Mateo grant site closure. More details about the recommended remedial activities are provided below.

Soil Excavation in Areas Impacted by Arsenic and Lead

Soil should be excavated from the two areas where the concentrations of lead and arsenic in soil exceed the SSTLs. For arsenic, soil should be excavated to the SSTL of 22 mg/kg (Table 10), which is consistent with soil background concentrations in the area. For lead, soil should be excavated to a target level of 1,000 mg/kg lead, which is the USEPA PRG for a commercial/industrial site use. Excavated soil containing arsenic and lead should be stockpiled, sampled and characterized, and disposed off-site at an approved waste management facility. A work plan should be prepared describing the sampling methods to confirm that soil containing arsenic and lead exceeding target levels have been removed. The work plan should contain provisions for control of dust, and for protection of on-site workers, and off-site workers during the soil excavation and transportation activities.

Soil Excavation in Areas Impacted by VOCs

Excavation at the former Tank Farm area should be performed to remove soil with VOCs at concentrations near saturation. For xylene this corresponds to a target level of 496 mg/kg. The excavated soil should be stockpiled, sampled and characterized for off-site disposal at an approved waste management facility. A work plan should be prepared as described above for the handling and disposal of soil. Sampling of the sides and bottom of the excavation should be performed in accordance with the plan to document that soil exceeding the target level has been removed.

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Backfilling

The excavation areas should be backfilled with clean soil to an elevation approximately equal to the original grade. The backfilled soil should be properly compacted to reduce the potential for settlement. The work plan should provide recommendations for proper backfilling methods, a recommended relative percentage of compaction and field density testing methods.

Management of Excavation Water

In the former Tank Farm area it is anticipated that soil excavation may extend to the top of the groundwater table. The depth of excavation of soil will not extend deeper than the groundwater table. While free product is not anticipated at the groundwater table, we recommend that the work plan include an option to use a vacuum truck to remove limited amounts of groundwater from the excavation at the former Tank Farm. The removal of groundwater from the excavation would be an immediate remedial method to remove residual VOCs and SVOCs in groundwater.

Plume Extent Delineation

The downgradient extent of the groundwater plume containing VOCs and SVOCs should be evaluated. An exploration plan should be developed to collect grab groundwater samples downgradient of the former Tank Farm. The exploration plan would include locating groundwater sampling points along the eastern property line, and within the public right-of-way of Linden Street east of the former Tank Farm. Geoprobe or direct push methods could be used to collect grab groundwater samples. Groundwater samples should be analyzed for the VOC and SVOC compounds found near the former Tank Farm.

Evaluation of Plume Stability

Based upon the results of laboratory analyses of grab groundwater samples, several groundwater monitoring wells should be installed to monitor the stability of the groundwater plume. A minimum of three groundwater monitoring wells should be installed to evaluate the groundwater gradient. One groundwater monitoring well should be located near Boring 13. One groundwater monitoring well should be located at the downgradient limit of the groundwater plume. A third groundwater monitoring well should be located in an upgradient location to provide background groundwater quality information.

The groundwater wells should be sampled quarterly and the samples analyzed in the laboratory to evaluate changes in concentrations of VOCs and SVOCs in groundwater to verify plume stability. Groundwater levels should be measured to evaluate changes in groundwater gradient each quarter. It is anticipated that at a minimum four quarters of groundwater monitoring may be required to provide an evaluation of the stability of the plume.

Natural Attenuation

Based upon the comparison of VOC and SVOC detections in groundwater to SSTLs we believe that the site may be redeveloped for commercial/industrial use without the need for active remediation of the groundwater plume. Following source removal, and documentation of plume

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stability, natural attenuation and degradation of the VOC and SVOC compounds in groundwater is the remedial option considered most suitable for this site.

Arsenic in Groundwater

At one groundwater sampling location (Boring 22), at the north corner of the site, the concentration of arsenic in groundwater is reported at 0.113 mg/l, which exceeds the SSTL of 0.050 mg/l. At that location the site is about 100 feet wide with the upgradient property line about 25 away. A railroad right-of-way off-site is located upgradient of Boring 22. To explore for evidence of an upgradient source we recommend that several grab groundwater samples be collected from near the property boundary upgradient of Boring 22 and be analyzed in the laboratory for arsenic. We also recommend that several grab groundwater samples be collected from locations at the property line downgradient of Boring 22 for arsenic analysis. The results of groundwater sampling and analysis should be evaluated to establish the extent of groundwater with arsenic exceeding the SSTL and whether further actions are needed. The SSTL for arsenic is established as the Maximum Contaminant Level for drinking water. This is a conservative approach for an industrial/commercial use of this site where there is a low potential for groundwater to be used as a drinking water source. Further actions may therefore not be needed once soil containing arsenic is removed and the groundwater is characterized.

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TABLE 1. SUMMARY OF LABORATORY ANALYSIS RESULTS FOR SOIL SAMPLES [mg/kg]

[illegible]

Warning: Do not use this product if you are pregnant or nursing. Do not use if you are allergic to any of the ingredients. Do not use if you are taking any other medication. Do not use if you are taking any other medication. Do not use if you are taking any other medication.

TABLE 2. SUMMARY OF LABORATORY ANALYSIS RESULTS FOR WATER SAMPLES (mg/L)

Sample ID	SSF-G-01-12	SSF-G-01-13	SSF-G-01-14	SSF-G-01-15	SSF-G-01-16	SSF-G-01-17	SSF-G-01-18	SSF-G-01-19	SSF-G-01-20	SSF-G-01-21	SSF-G-01-22
Sampling Date	10/2/94	10/2/94	10/2/94	10/2/94	10/2/94	10/2/94	10/2/94	10/2/94	10/2/94	10/2/94	10/2/94
Depth to Water (ft)	7.0	13.0	14.0	5.0	4.0	11.0	6.0	7.0	12.0	10.0	9.0
THM by EPA Method 8131 and EPA Method 8160											
THM	0.4	<0.02	0.06	0.06	<0.001	0.001	<0.001	—	0.022	<0.001	<0.001
Trihalomethanes	1.8	1.4	38	149	<0.001	0.004	<0.001	—	<0.005	<0.001	<0.001
Trihaloethenes	5.8	0.27	3.1	8.9	<0.001	0.001	<0.001	—	0.007	<0.001	<0.001
Total Trihalomethanes	31	1.5	13	38	<0.001	0.009	<0.001	—	0.032	<0.001	<0.001
THM-Disinfection Byproduct	4.1	4.2	1.2	9	—	0.0	0.03	—	—	—	0.01
THM-Disinfection Byproduct	309	28	97	219	<0.01	0.12	<0.01	—	3.2	<0.01	1.3
HCO ₃ by EPA Method 8090 (Distilled samples only)											
Acetone	539	13	11	2.2	<0.02	<0.02	<0.02	—	0.077	<0.02	<0.02
1,2-Dichloroethane	32	0.22	<0.1	<0.1	<0.01	<0.01	<0.01	—	0.017	<0.01	<0.01
1,2-Dichloroethene	<0.2	<0.02	<0.1	<0.1	<0.01	<0.01	<0.01	—	0.016	<0.01	<0.01
4-Methyl-2-pentanol	64	0.29	<0.1	<0.1	<0.01	<0.01	<0.01	—	<0.01	<0.01	<0.01
HCO ₃ by EPA Method 8174 (Distilled samples only)											
Diethylamine	<0.01	<0.01	<0.01	0.06	<0.01	<0.01	<0.01	—	<0.01	<0.01	<0.01
Diethylamine	0.03	<0.01	<0.01	0.034	<0.01	<0.01	<0.01	—	<0.01	<0.01	<0.01
Diethylamine	0.046	0.1	<0.01	<0.01	<0.01	<0.01	<0.01	—	<0.01	<0.01	<0.01
Diethylamine	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	—	<0.01	<0.01	<0.01
Diethylamine	0.13	<0.01	0.13	0.13	<0.01	<0.01	<0.01	—	0.04	<0.01	<0.01
Diethylamine	0.17	<0.01	0.17	0.17	<0.01	<0.01	<0.01	—	<0.01	<0.01	<0.01
Diethylamine	0.041	<0.01	<0.01	0.041	<0.01	<0.01	<0.01	—	0.011	<0.01	<0.01
Diethylamine	0.05	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	—	0.011	<0.01	<0.01
Diethylamine	0.05	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	—	<0.01	<0.01	<0.01
PCB by EPA Method 8082											
PCB	—	—	—	—	—	—	—	<0.005	—	—	—
THM-20 Method by EPA Method 8090											
Acetone	<0.2	—	—	<0.2	<0.2	<0.2	<0.2	—	—	—	<0.2
Acetone	0.032	—	—	0.032	0.032	0.032	0.032	—	—	—	0.032
Acetone	0.17	—	—	<0.1	<0.1	<0.1	<0.1	—	—	—	<0.1
Acetone	0.179	—	—	0.179	0.179	0.179	0.179	—	—	—	0.179
Acetone	<0.01	—	—	<0.01	<0.01	<0.01	<0.01	—	—	—	<0.01
Acetone	<0.03	—	—	<0.03	<0.03	<0.03	<0.03	—	—	—	<0.03
Acetone	<0.05	—	—	<0.05	<0.05	<0.05	<0.05	—	—	—	<0.05
Acetone	0.03	—	—	0.03	0.03	0.03	0.03	—	—	—	0.03
Acetone	<0.01	—	—	<0.01	<0.01	<0.01	<0.01	—	—	—	<0.01
Acetone	<0.0002	—	—	<0.0002	<0.0002	<0.0002	<0.0002	—	—	—	<0.0002
Acetone	0.05	—	—	<0.05	<0.05	<0.05	<0.05	—	—	—	<0.05
Acetone	<0.01	—	—	<0.01	<0.01	<0.01	<0.01	—	—	—	<0.01
Acetone	<0.02	—	—	<0.02	<0.02	<0.02	<0.02	—	—	—	<0.02
Acetone	<0.02	—	—	<0.02	<0.02	<0.02	<0.02	—	—	—	<0.02
Acetone	<0.02	—	—	<0.02	<0.02	<0.02	<0.02	—	—	—	<0.02
Acetone	0.039	—	—	0.039	0.039	0.039	0.039	—	—	—	0.039

Notes:
Results above detection limit are bolded.

TABLE 3. TIER 1 COMPARISON OF SOIL MAXIMUM DETECTIONS WITH PRGs

Sample ID	Number of Samples Analyzed	Number of Detections	Average Detected Conc. (mg/kg)	Maximum Detection (mg/kg)	Location of Maximum Detection	Industrial Soil PRG (mg/kg)	Is Soil PRG Exceeded by Max. Conc.?
PTX and TPA by EPA Method 814-824 and EPA Method 824 (detected analytes only and summed for risk score)							
Toluene	24	17	31	200	SSP-3-SB-12-3-4	520	NO
Ethylbenzene	24	16	16	85	SSP-3-SB-15-3-4	220	NO
Total Xylenes	24	16	79	490	SSP-3-SB-13-3-4	210	PRG Exceeded
TPH (Dist)	27	15	323	2,000	SSP-3-S1-0-1	na	NO
TPH (Condens)	24	13	230	870	SSP-3-SB-14-3-2	na	NO
VOCs by EPA Method 8140 (detected analytes only)							
Acetone	10	2	37	77	SSP-3-SB-13-3-9	6,630	NO
2-Propanol	10	1	3.3	3.3	SSP-3-SB-13-3-9	27,200	NO
SVOCs by EPA Method 8160 (detected analytes only)							
Acenaphthene	21	3	3.4	3.9	SSP-3-SB-12-3-4	20,000	NO
Anthracene	21	3	2.2	2.6	SSP-3-SB-12-3-9	232,000	NO
Benzo(a)anthracene	21	3	1.4	1.7	SSP-3-SB-12-3-9	3.59	NO
Benzo(b)fluoranthene	21	2	0.8	0.8	SSP-3-SB-12-3-4	3.59	NO
Benzo(k)fluoranthene	21	2	0.5	0.5	SSP-3-SB-12-3-4	6,500	PRG Exceeded
Benzo(a)pyrene	21	2	17.5	18	SSP-3-SB-12-3-9	930	NO
Benzo(g,h,i)perylene	21	3	0.8	0.8	SSP-3-SB-12-3-1 and -3-9	150	NO
Chrysene	21	3	1.2	1.3	SSP-3-SB-12-3-4 and -3-9	359	NO
Dibenzofuran	21	3	2.6	2.9	SSP-3-SB-12-3-1 and -3-9	3,240	NO
1,4-Dimethylbenzol	21	3	0.6	0.7	SSP-3-SB-13-3-4	21,400	NO
Dibenzophthalate	21	6	226	1,000	SSP-3-SB-15-3-4	197,000	NO
Fluoranthene	21	1	4.2	4.2	SSP-3-SB-13-0-1	37,400	NO
Phenanthrene	21	3	4.3	4.9	SSP-3-SB-12-3-1 and -3-9	22,400	NO
2-Methylanthracene	21	4	2.9	3.8	SSP-3-SB-12-3-4 and -3-9	na	NO
2-Methylbenzol	21	2	0.8	0.8	SSP-3-SB-12-3-9	53,400	NO
3- and 4-Methylbenzol	21	2	0.6	0.7	SSP-3-SB-13-3-9	5,540	NO
Naphthalene	21	4	2.5	3.4	SSP-3-SB-13-3-9	188	NO
Fluorenone	21	3	10	13	SSP-3-SB-12-3-4 and -3-9	na	NO
Pyrene	21	3	4	5	SSP-3-SB-15-3-9	26,300	NO
116 22 Metals by EPA Method 6010 (detected analytes only)							
Arsenic	11	11	29	194	SSP-3-S1-0-1	2.89	PRG Exceeded
Barium	11	11	97	278	SSP-3-S1-0-1	100,000	NO
Beryllium	11	8	0.3	0.3	SSP-3-S1-0-1	3,400	NO
Cadmium	11	4	1.5	2.3	SSP-3-S1-0-1	934	NO
Chromium	11	11	54	108	SSP-3-S1-0-1	448	NO
Cobalt	11	11	6.1	8.4	SSP-3-S1-0-1	28,600	NO
Copper	11	11	21	67	SSP-3-S1-0-1	69,600	NO
Lead	11	11	494	4,900	SSP-3-S1-0-1	1,800	PRG Exceeded
Mercury	11	2	0.3	0.3	SSP-3-S1-0-1	302	NO
Nickel	11	11	35	67	SSP-3-S1-0-1	37,300	NO
Vanadium	11	11	32	49	SSP-3-SB-15-0-1	13,100	NO
Zinc	11	11	195	778	SSP-3-S1-0-1	100,000	NO

Notes:
 PRG = Preliminary Remedial Goal, USEPA 1998, Region 9 PRG Tables, May.
 Exceedance of PRG are bolded.

TABLE 4. TIER 1 COMPARISON OF WATER MAXIMUM DETECTIONS WITH WATER QUALITY CRITERIA

Sample ID	Number of Samples Analyzed	Number of Detections	Average Detection (mg/L)	Maximum Detection (mg/L)	Location of Maximum Detection	Water Quality Criteria (WQC) and Reference (mg/L)	Is WQC Exceeded by Max. Detection?
TPH by EPA Method 8015/8020 and EPA Method 8160 (detected analytes only)							
Benzene	10	5	0.11	0.4	SSF-G-SB-12	0.001 MCL	WQC Exceeded
Toluene	10	5	56.7	189	SSF-G-SB-12	0.15 MCL	WQC Exceeded
Ethylbenzene	10	7	2.6	8.9	SSF-G-SB-15	0.7 MCL	WQC Exceeded
Total Xylenes	10	6	12.7	39	SSF-G-SB-15	1.75 MCL	WQC Exceeded
TPH-Diesel	7	7	3.7	9.1	SSF-G-SB-12	n/a	NO
TPH-Gasoline	10	7	102	380	SSF-G-SB-12	n/a	NO
VOCs by EPA Method 8160 (detected analytes only)							
Acetone	10	5	111	630	SSF-G-SB-12	0.608 PRG	WQC Exceeded
2-Butanone	10	3	7.4	22	SSF-G-SB-12	1.9 PRG	WQC Exceeded
1,2-Dichloroethane	10	1	0.016	0.016	SSF-G-SB-21	0.0005 MCL	WQC Exceeded
4-Methyl-2-pentanone	10	2	22	44	SSF-G-SB-12	n/a	NO
SVOCs by EPA Method 8170 (detected analytes only)							
Diethylphthalate	10	1	0.08	0.08	SSF-G-SB-15	n/a	NO
2,4-Dimethylphenol	10	2	0.031	0.034	SSF-G-SB-15	0.4 AL	NO
Di-n-butylphthalate	10	3	1.7	4.1	SSF-G-SB-13	3.45 PRG	WQC Exceeded
2-Methylnaphthalene	10	1	0.029	0.029	SSF-G-SB-20	n/a	NO
2-Methylphenol	10	3	0.08	0.12	SSF-G-SB-15	1.83 PRG	NO
4-Methylphenol	10	3	0.11	0.17	SSF-G-SB-12	1.85 PRG	NO
Naphthalene	10	3	0.28	0.79	SSF-G-SB-20	6.2 PRG	NO
Phenol	10	2	0.02	0.02	SSF-G-SB-11	21.9 PRG	NO
Title 22 Metals by EPA Method 6010 (detected analytes only)							
Arsenic	6	5	0.04	0.113	SSF-G-SB-22	0.05 MCL	WQC Exceeded
Barium	6	1	0.17	0.17	SSF-G-SB-12	1 MCL	NO
Boron	6	6	0.19	0.235	SSF-G-SB-17	1 AL	NO
Chromium	6	1	0.046	0.046	SSF-G-SB-18	0.05 MCL	NO
Copper	6	5	0.037	0.046	SSF-G-SB-18	1 MCL	NO
Nickel	6	3	0.07	0.08	SSF-G-SB-22	0.1 MCL	NO
Vanadium	6	1	0.042	0.042	SSF-G-SB-18	0.256 PRG	NO
Zinc	6	3	0.03	0.041	SSF-G-SB-18	5 MCL	NO

Notes:

MCL = Maximum Contaminant Level. Cal EPA-DTSC 1994. Summary of California Drinking Water Standards. November.

AL = Action Level. Cal EPA-DTSC 1994. Summary of California Drinking Water Standards. November.

PRG = Preliminary Remedial Goal. USEPA 1998. Region 9 PRG Tables. May.

Exceedances of WQC are bolded.

TABLE 5. COMMERCIAL EXPOSURE FACTORS AND ENVIRONMENTAL PARAMETERS

PARAMETER	Units	Value	References
EXPOSURE PARAMETERS			
Averaging Time for Carcinogens	yr	70	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Averaging Time for Noncarcinogens	yr	25	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Body Weight Adult	kg	70	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Exposure Duration Adult	yr	25	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Exposure Frequency	days/yr	250	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Soil Ingestion Rate Adult	mg/day	50	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Daily Indoor Inhalation Rate Adult	m ³ /day	20	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Daily Outdoor Inhalation Rate Adult	m ³ /day	20	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Soil to Skin Adherence Factor	mg/cm ²	0.5	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Oral Relative Absorption Factor	—	1	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Skin Surface Area Adult	cm ²	3,100	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Target Hazard Quotient for Individual Constituents	—	1	NCP's hazard threshold (USEPA 1990)
Target Excess Individual Lifetime Cancer Risk	—	1.0E-6	Lowest order of magnitude of NCP's acceptable risk range (USEPA 1990)
ENVIRONMENTAL FATE AND TRANSPORT PARAMETERS			
Lower depth of surficial soil zone	cm	100	ASTM Default Value (ASTM 1995)
Enclosed space air exchange rate	1/hr	0.0014	five volume exchanges per hour - forced ventilation
Fraction of organic carbon in soil	g-C/g-soil	0.01	ASTM Default Value (ASTM 1995)
Thickness of capillary fringe	cm	5	ASTM Default Value (ASTM 1995)
Thickness of vadose zone	cm	205	about 7 feet, based on field observations
Enclosed space ventilation/filtration area	cm	300	ASTM Default Value (ASTM 1995)
Enclosed space foundation/wall thickness	cm	15	ASTM Default Value (ASTM 1995)
Depth to ground water	cm	210	about 7 feet, based on field observations
Depth to subsurface soil sources	cm	100	ASTM Default Value (ASTM 1995)
Particulate emission rate	g/cm ² -s	6.9E-14	ASTM Default Value (ASTM 1995)
Wind speed above ground surface in ambient mixing zone	cm/s	225	ASTM Default Value (ASTM 1995)
Width of source area parallel to wind or gr flow	cm	1500	ASTM Default Value (ASTM 1995)
Ambient air mixing zone height	cm	200	ASTM Default Value (ASTM 1995)
Area fraction of cracks in foundation/walls	cm ² /cm ²	0.001	good condition pavement
Volumetric air content in capillary fringe soils	cc/cc	0.638	ASTM Default Value (ASTM 1995)
Volumetric air content in found/wall cracks	cc/cc	0.36	ASTM Default Value (ASTM 1995)
Volumetric air content in vadose zone soils	cc/cc	0.36	ASTM Default Value (ASTM 1995)
Total soil porosity	cc/cc-soil	0.38	ASTM Default Value (ASTM 1995)
Volumetric water content in capillary fringe soils	cc/cc	0.342	ASTM Default Value (ASTM 1995)
Volumetric water content in found/wall cracks	cc/cc	0.12	ASTM Default Value (ASTM 1995)
Volumetric water content in vadose zone soils	cc/cc	0.12	ASTM Default Value (ASTM 1995)
Soil bulk density	g/cc	1.7	ASTM Default Value (ASTM 1995)
Averaging time for vapor flux	sec	7.88E+8	ASTM Default Value (ASTM 1995)

References

Cal/EPA. 1992. Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities. OSA. July.
 Cal/EPA. 1994. Preliminary Endangerment Guidance Manual. DTSC. January.
 ASTM. 1995. Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites. E 1739-95. November.
 USEPA. 1990. 40 CFR Part 300. National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Final Rule. 55(46): 8640-8669. March 8.

TABLE 6. CONSTRUCTION EXPOSURE FACTORS AND ENVIRONMENTAL PARAMETERS

PARAMETER	Units	Value	Reference
EXPOSURE PARAMETERS			
Averaging Time for Carcinogens	yr	70	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Averaging Time for Noncarcinogens	yr	25	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Body Weight Adult	kg	70	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Exposure Duration Adult	yr	0.17	two months
Exposure Frequency	days/yr	250	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Soil Ingestion Rate Adult	mg/day	80	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Daily Indoor Inhalation Rate Adult	m ³ /day	0.83	assumes working one hour per day in trenches
Daily Outdoor Inhalation Rate Adult	m ³ /day	5.83	assumes working seven hours per day outdoor
Daily Water Ingestion Rate Adult	L/day	1	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Soil to Skin Adherence Factor	mg/cm ²	0.5	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Oral Relative Absorption Factor	—	1	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Skin Surface Area Adult	cm ²	3,160	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Target Hazard Quotient for Individual Constituents	—	1	NCP's hazard threshold (USEPA 1990)
Target Excess Individual Lifetime Cancer Risk	—	1.0E-6	Lowest order of magnitude of NCP's acceptable risk range (USEPA 1990)
ENVIRONMENTAL FATE AND TRANSPORT PARAMETERS			
Lower depth of surficial soil zone	cm	100	ASTM Default Value (ASTM 1995)
Enclosed space air exchange rate	1/sec	0.0028	ten volume exchanges per hour - trenches
Fraction of organic carbon in soil	g-C/g-soil	0.01	ASTM Default Value (ASTM 1995)
Thickness of capillary fringe	cm	5	ASTM Default Value (ASTM 1995)
Thickness of vadose zone	cm	5	assumes bottom of excavation almost at the water table
Infiltration rate of water through soil	cm/yr	30	ASTM Default Value (ASTM 1995)
Enclosed space volume/infiltration area	cm	300	ASTM Default Value (ASTM 1995)
Enclosed space foundation/wall thickness	cm	15	ASTM Default Value (ASTM 1995)
Depth to groundwater	cm	5	assumes bottom of excavation almost at the water table
Depth to subsurface soil sources	cm	1	assumes bottom of excavation reaches contaminated soil
Particulate emission rate	g/cm ³ -s	1.5E-9	selected to correspond to 0.05 mg/m ³ PM ₁₀ concentration
Wind speed above ground surface in ambient mixing zone	cm/s	225	ASTM Default Value (ASTM 1995)
Width of source area parallel to wind or gw flow	cm	1500	ASTM Default Value (ASTM 1995)
Ambient air mixing zone height	cm	200	ASTM Default Value (ASTM 1995)
Area/ fraction of cracks in foundation/walls	cm ² /cm ²	0.999	no soil cover in trenches
Volumetric air content in capillary fringe soils	cc/cc	0.038	ASTM Default Value (ASTM 1995)
Volumetric air content in found/wall cracks	cc/cc	0.26	ASTM Default Value (ASTM 1995)
Volumetric air content in vadose zone soils	cc/cc	0.26	ASTM Default Value (ASTM 1995)
Total soil porosity	cc/cc-soil	0.38	ASTM Default Value (ASTM 1995)
Volumetric water content in capillary fringe soils	cc/cc	0.342	ASTM Default Value (ASTM 1995)
Volumetric water content in found/wall cracks	cc/cc	0.12	ASTM Default Value (ASTM 1995)
Volumetric water content in vadose zone soils	cc/cc	0.12	ASTM Default Value (ASTM 1995)
Soil bulk density	g/cc	1.7	ASTM Default Value (ASTM 1995)
Averaging time for vapor flux	sec	7.88E+8	ASTM Default Value (ASTM 1995)

References:

- Cal/EPA. 1992. Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities. OSA, July.
 Cal/EPA. 1994. Preliminary Endangerment Guidance Manual. DTSC, January.
 ASTM. 1995. Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites. E 1739-95. November.
 USEPA. (1990). 40 CFR Part 300. National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Final Rule. 55(46): 8640-8669. March 0.

TABLE 7. RESIDENTIAL EXPOSURE FACTORS AND ENVIRONMENTAL PARAMETERS

PARAMETER	Units	Value	Reference
EXPOSURE PARAMETERS			
Averaging Time for Carcinogens	yr	70	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Averaging Time for Noncarcinogens	yr	30	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Body Weight Adult	kg	70	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Exposure Duration Adult	yr	34	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Exposure Frequency	days/yr	360	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Soil Ingestion Rate Adult	mg/day	100	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Daily Indoor Inhalation Rate Adult	m ³ /day	15	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Daily Outdoor Inhalation Rate Adult	m ³ /day	20	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Soil to Skin Adherence Factor	mg/cm ²	0.5	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Oral Relative Absorption Factor	—	1	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Skin Surface Area Adult	cm ²	3,160	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Body Weight Child	kg	15	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Exposure Duration Child	yr	6	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Soil Ingestion Rate Child	mg/day	200	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Daily Indoor Inhalation Rate Child	m ³ /day	15	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Daily Outdoor Inhalation Rate Child	m ³ /day	10	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Skin Surface Area Child	cm ²	2,000	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Target Hazard Quotient for Individual Constituents	—	1	NCP's hazard threshold (USEPA 1990)
Target Excess Individual Lifetime Cancer Risk	—	1.0E-6	Lowest order of magnitude of NCP's acceptable risk range (USEPA 1990)
ENVIRONMENTAL FATE AND TRANSPORT PARAMETERS			
Lower depth of surficial soil zone	cm	100	ASTM Default Value (ASTM 1995)
Enclosed space air exchange rate	1/hr	0.00028	natural ventilation - one volume per hour (Walsh et al. 1984)*
Fraction of organic carbon in soil	p-C _{org} -soil	0.01	ASTM Default Value (ASTM 1995)
Thickness of capillary fringe	cm	5	ASTM Default Value (ASTM 1995)
Thickness of vadose zone	cm	200	about 7 feet, based on field observations
Enclosed space volume/infiltration area	cm	200	ASTM Default Value (ASTM 1995)
Enclosed space foundation/wall thickness	cm	15	ASTM Default Value (ASTM 1995)
Depth to groundwater	cm	230	about 7 feet, based on field observations
Depth to subsurface soil sources	cm	100	ASTM Default Value (ASTM 1995)
Particulate emission rate	g/cm ² -s	6.9E-14	ASTM Default Value (ASTM 1995)
Wind speed above ground surface in ambient mixing zone	cm/s	200	ASTM Default Value (ASTM 1995)
Width of source area parallel to wind or gw flow	cm	1500	ASTM Default Value (ASTM 1995)
Ambient air mixing zone height	cm	200	ASTM Default Value (ASTM 1995)
Areal fraction of cracks in foundation/walls	cm ² /cm ²	0.001	good condition pavement
Volumetric air content in capillary fringe soils	cc/cc	0.038	ASTM Default Value (ASTM 1995)
Volumetric air content in found./wall cracks	cc/cc	0.26	ASTM Default Value (ASTM 1995)
Volumetric air content in vadose zone soils	cc/cc	0.26	ASTM Default Value (ASTM 1995)
Total soil porosity	cc/cc-soil	0.38	ASTM Default Value (ASTM 1995)
Volumetric water content in capillary fringe soils	cc/cc	0.343	ASTM Default Value (ASTM 1995)
Volumetric water content in found./wall cracks	cc/cc	0.12	ASTM Default Value (ASTM 1995)
Volumetric water content in vadose zone soils	cc/cc	0.12	ASTM Default Value (ASTM 1995)
Soil bulk density	g/cc	1.7	ASTM Default Value (ASTM 1995)
Averaging time for vapor flux	sec	7.88E+8	ASTM Default Value (ASTM 1995)

References:

- Cal/EPA. 1992. Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities. OSA. July.
 Cal/EPA. 1994. Preliminary Exchangeable Guidance Manual. DTSC. January.
 ASTM. 1995. Standard Guide for Risk-Based Corrective Action Applied to Petroleum Release Sites. E 1738-95. November.
 USEPA. 1990. 40 CFR Part 300. National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Final Rule. 55(46): 8640-8669. March 8.
 Walsh, J., et al. 1984. Indoor Air Quality. CRC Press.

TABLE 8. CHEMICAL-SPECIFIC TOXICITY PARAMETERS

CHEMICAL	SLOPE FACTOR		REFERENCE DOSE		ABS [-]
	ORAL [mg/kg-day]	Ref.	ORAL [mg/kg-day]	INHALATION [mg/kg-day]	
Benzene	1.1E-1	CalEPA	3.0E-3	NCEA	0.5
Toluene	na	ASTM	2.0E-1	ASTM	0.5
Ethylbenzene	na	ASTM	1.0E-1	ASTM	0.5
Xylene (mixed)	na	ASTM	2.0E-1	ASTM	0.5
Naphthalene	na	ASTM	2.0E-2	IRIS	0.05
Benz(a)pyrene	1.2E-1	CalEPA	na	ASTM	0.05
1,2-Dichloroethane (EDC)	7.0E-2	CalEPA	2.9E-3	R. to R.	0.1
3-Butanone (MEK)	na	-	6.0E-1	IRIS	0.1
Acetone	na	-	1.0E-1	IRIS	0.1
Dibutyl phthalate	na	-	1.0E-1	IRIS	0.1
Arsenic (cancer endpoint)	1.5E-1	IRIS	3.0E-4	IRIS	0.03
Arsenic (noncancer endpoint)	na	-	3.0E-4	IRIS	0.03
Lead	na	-	na	na	-

References (in order of priority)

CalEPA = CalEPA, 1994. Memorandum on California Cancer Potency Factors: Update 11/94.

IRIS, NCEA, HEAST, R. to R., WTDNR) = As referenced in US EPA Region 9 Preliminary Remediation Goals (PRGs) 1998.

IRIS = Integrated Risk Information System (IRIS), Online Database USEPA (1998).

HEAST, NCEA = Health Effects Assessment Summary Tables (HEAST), Annual Update, National Center for Exposure Assessment, USEPA (1997).

R. to R. = Route-to-route extrapolation.

WTDNR = withdrawn

ABS = Dermal Absorption Factor.

na = Not Applicable/Not Available.

TABLE 9. CHEMICAL-SPECIFIC FATE AND TRANSPORT PARAMETERS

CHEMICAL	K _{oc} (cm ² /g)	R (cm ² /mol)	H* = H/RT [-]	Solubility (mg/L)	D _{air} (cm ² /sec)	D _{water} (cm ² /sec)
Benzene	6.5E+4	5.5E+3	2.3E-1	1.8E+3	9.3E-2	1.1E-5
Toluene	1.4E+2	6.6E+3	2.7E-1	5.4E+2	8.9E-2	9.4E-6
Ethylbenzene	2.2E+2	7.9E+3	3.2E-1	1.5E+2	7.6E-2	8.5E-6
Xylene (ortho)	2.4E+2	5.3E+3	2.2E-1	2.0E+2	8.7E-2	8.5E-6
Naphthalene	1.3E+3	1.3E+3	3.3E-2	3.1E+1	7.2E-2	9.4E-6
Benz(a)pyrene	3.9E+5	1.4E+9	5.7E-4	1.2E+3	5.0E-2	5.8E-6
1,3-Dichlorobenzene (DCB)	3.8E+1	9.8E+4	4.0E-2	8.5E+3	1.0E-1	9.9E-6
2-Bromonaphthalene (BREN)	4.5E+0	2.7E+5	1.1E-3	2.7E+5	9.0E-2	9.8E-6
Acetone	5.8E-1	3.9E+5	1.6E-3	1.8E+6	1.2E-1	1.1E-5
Dibutyl phthalate	na	na	na	na	na	na
Atrazine (cancer endpoint)	na	na	na	na	na	na
Atrazine (noncancer endpoint)	na	na	na	na	na	na
Lead	na	na	na	na	na	na

Definitions of Parameters
K_{oc} = Organic carbon partition coeff.
H = Henry's Law constant
D_{air} = Diffusion coefficient in air
D_{water} = Diffusion coefficient in water

H* = Dimensionless Henry's constant = H / (R T)
R = Universal Gas Constant
T = Absolute Temperature

References (in order of priority)

USEPA. 1998. Region 9 Preliminary Remediation Goals (PRGs). May.
ASTM 1995. Standard Guide for Risk-Based Corrective Action Applied to Petroleum Release Sites. E 1739-95.

TABLE 10. COMPARISON OF SOIL AVERAGE AND MAXIMUM DETECTIONS TO TIER 2 SSTLS

Chemicals of Concern (1)	Number of Samples Analyzed	Number of Detections	Average Detected Conc. (mg/kg)	Maximum Detection (mg/kg)	Location of Maximum Detection	1x10 ⁴ (1x10 ⁴) Risk or a Unit HQ			Does Max. Conc. Exceed SSTLs?
						Indoor Commercial SSTL (mg/kg)	Trench Construction SSTL (mg/kg)	Does Average Conc. Exceed SSTLs?	
Total Xylenes	24	16	79	490	SSF-S-SB-13-3-4	496 *	496 *	NO	NO
Benz(a)pyrene	21	2	0.5	0.5	SSF-S-SB-12-3-4	4.7 *	4.7 *	NO	NO
Arsenic	11	11	29	194	SSF-S-S1-0-1	22.0 PRG	54 (539) SS	NO	Exceeded
Lead	11	11	434	4,200	SSF-S-S1-0-1	1,000 PRG	1,000 PRG	NO	Exceeded

Notes:

Exceedences of SSTLs are bolded.

* Indicates that target risk level is not exceeded at soil saturation, and hence saturation is listed as SSTL.

SS, PRG = SSTL based on artificial soil exposure or PRG since chemical is not-volatile according to USEPA (1998)

PRG = Preliminary Remedial Goal, USEPA 1998, Region 9 PRG Tables. May.

PRG = Non-cancer endpoint for residential PRG, and also region-specific soil background threshold (see Appendix A-3)

TABLE 11. COMPARISON OF GROUNDWATER AVERAGE AND MAXIMUM DETECTIONS TO TIER 2 SSTLs

Chemicals of Concern (1)	Number of Samples Analyzed	Number of Detections	Average Detection (mg/L)	Maximum Detection (mg/L)	Location of Maximum Detection	1x10 ⁻⁴ (1x10 ⁻⁶) Risk or a Unit HQ			Does Average Conc. Exceed SSTL?	Does Max. Conc. Exceed SSTL?
						Indoor Commercial SSTL (mg/L)	Trench Construction SSTL (mg/L)			
Benzene	10	5	0.11	0.4	SSF-G-SB-12	0.56 (5.6)	1,750 *		NO	NO
Toluene	10	5	56.7	130	SSF-G-SB-12	535 *	535 *		NO	NO
Bibenzonene	10	7	2.6	8.9	SSF-G-SB-15	152 *	152 *		NO	NO
Total Xylenes	10	6	12.7	39	SSF-G-SB-15	198 *	198 *		NO	NO
Naphthalene	10	6	10.4	24	SSF-G-SB-20	31 *	31 *		NO	NO
Acetone	10	5	111	530	SSF-G-SB-12	>10%	>10%		NO	NO
2-Benzonene	10	3	7.4	22	SSF-G-SB-12	>10%	>10%		NO	NO
1,2-Dichloroethane	10	1	0.016	0.016	SSF-G-SB-21	4.34 (43.4)	656 (6,560)		NO	NO
Di-n-butylphthalate	10	3	1.7	5.1	SSF-G-SB-13	3.7 PRG	3.7 PRG		NO	SSTL Exceeded
Atricide	6	5	0.04	0.113	SSF-G-SB-22	0.05 MCL	0.05 MCL		NO	SSTL Exceeded

Notes:

Exceedances of SSTLs are bolded.

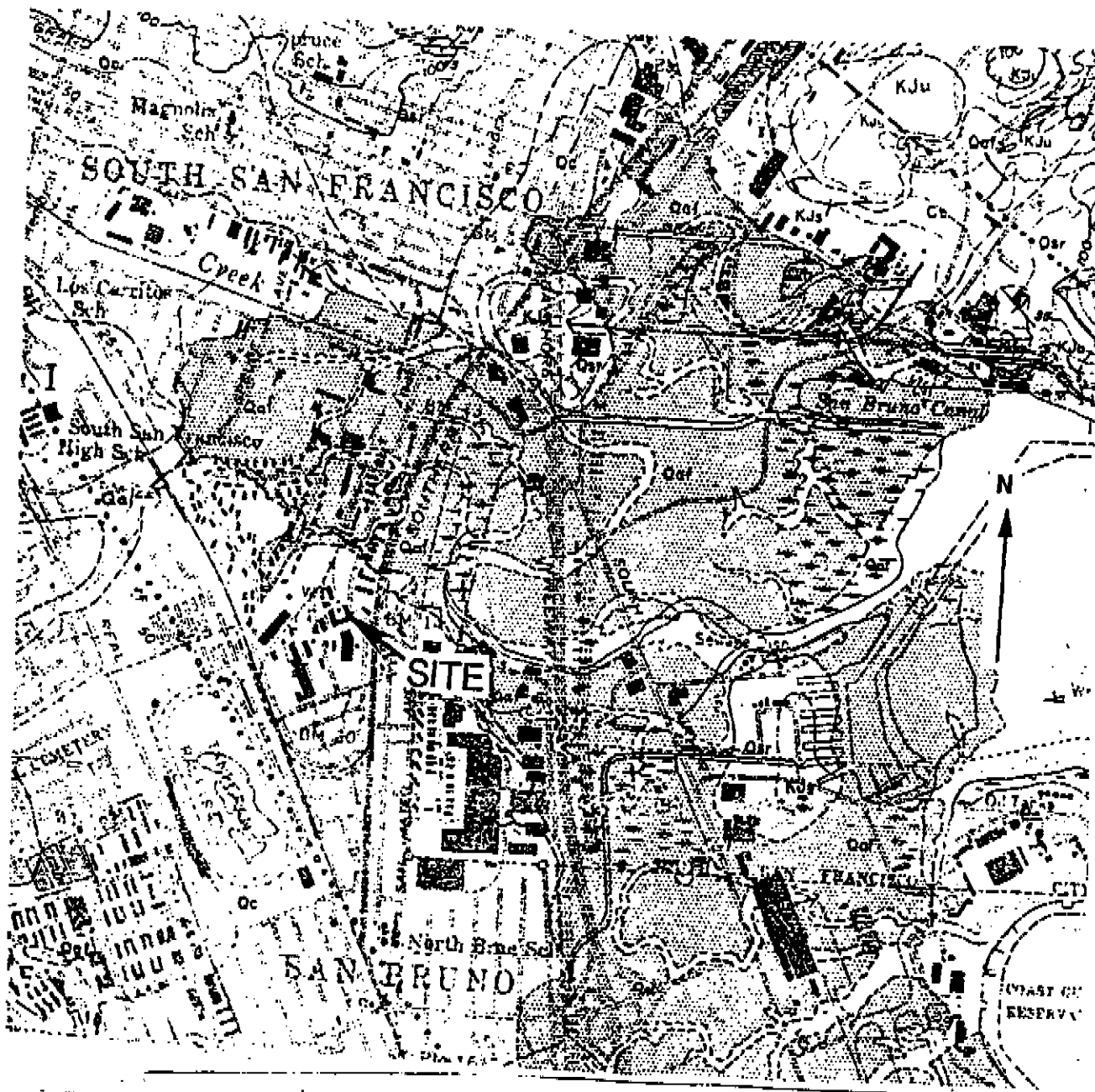
* Indicates that target risk level is not exceeded at water solubility, and hence solubility is listed as SSTL.

SS = SSTL based on PRG, MCL, or AL since chemical is non-volatile according to USEPA (1998). The drinking water criteria are used due to the lack of applicable risk-based criteria.

PRG = Preliminary Remedial Goal. USEPA 1998. Region 9 PRG Tables. May.

MCL = Maximum Contaminant Level. Cal EPA-DTSC 1994. Summary of California Drinking Water Standards. November.

AL = Action Level. Cal EPA-DTSC 1994. Summary of California Drinking Water Standards. November.



0 2000 4000
 Scale in Feet

LEGEND

Qafs/Qaf	Artificial Fill	QTm	Merced Formation
Qol	Alluvium	KJ	Franciscan Formation
Qm	Bay Mud		Approximate Area of Old Tidal Flats
Qsr	Slope debris and Ravine Fill		Fault, Dashed where Approximate, Dotted where Concealed
Qc	Colma Formation		Hypothetical Fault
			Strike and Dip of Beds

Project No.
 D6SF8071

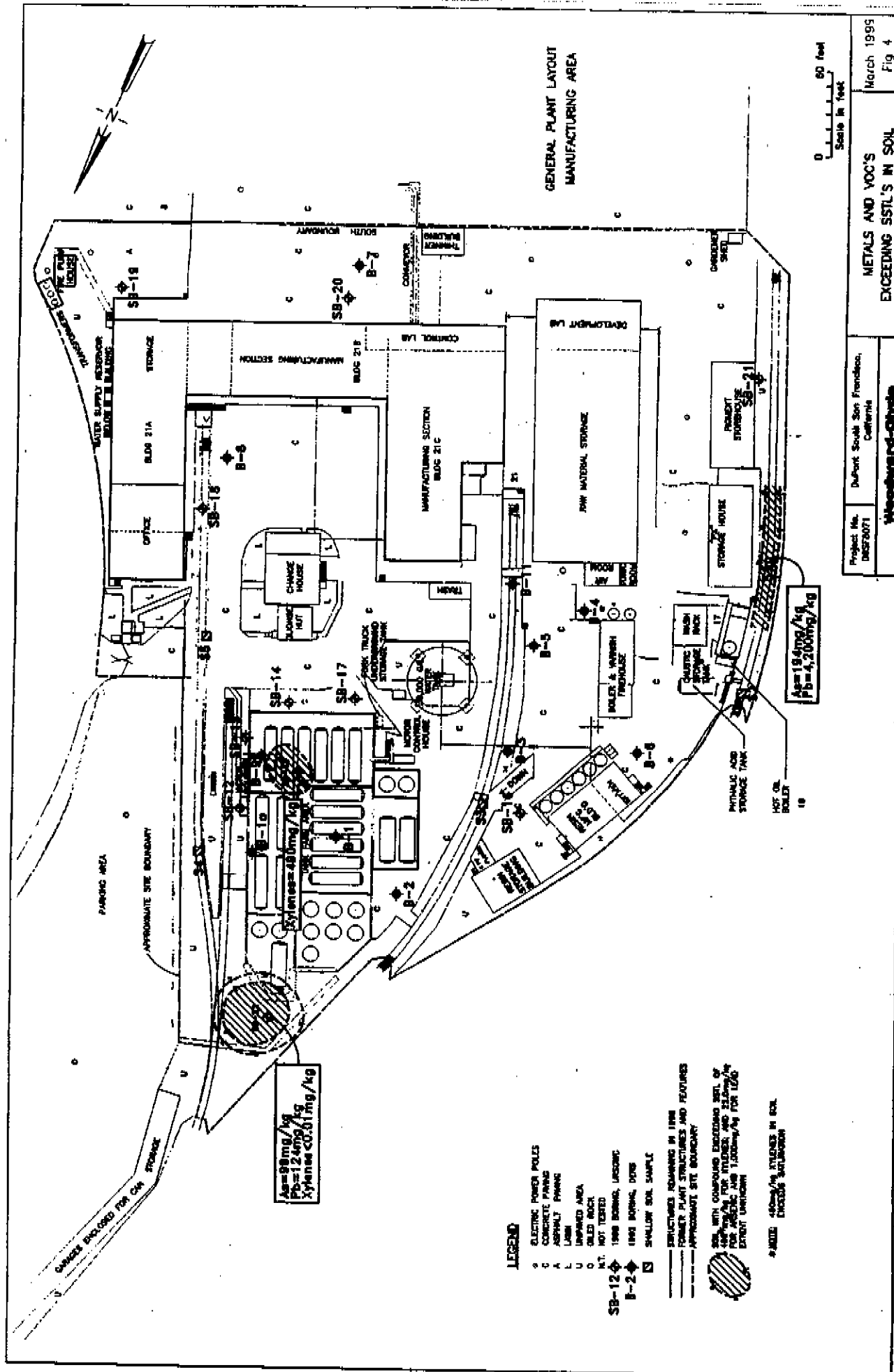
DUPONT

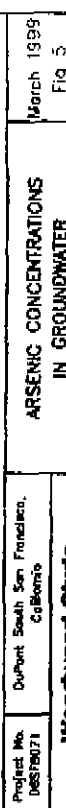
URS Greiner Woodward Clyde

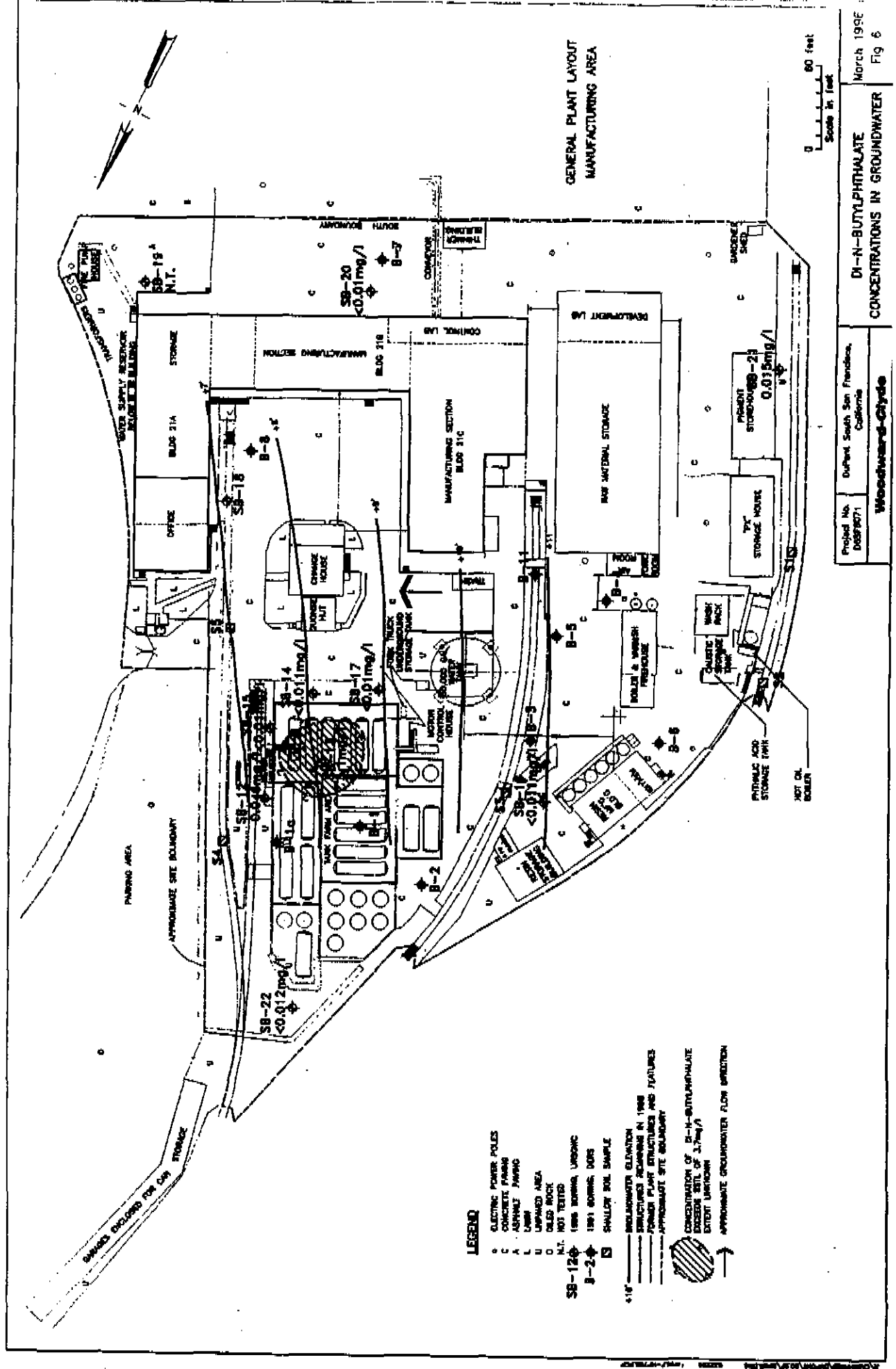
Site Location Map and Regional Geology

Dec. 1998

Fig. 1







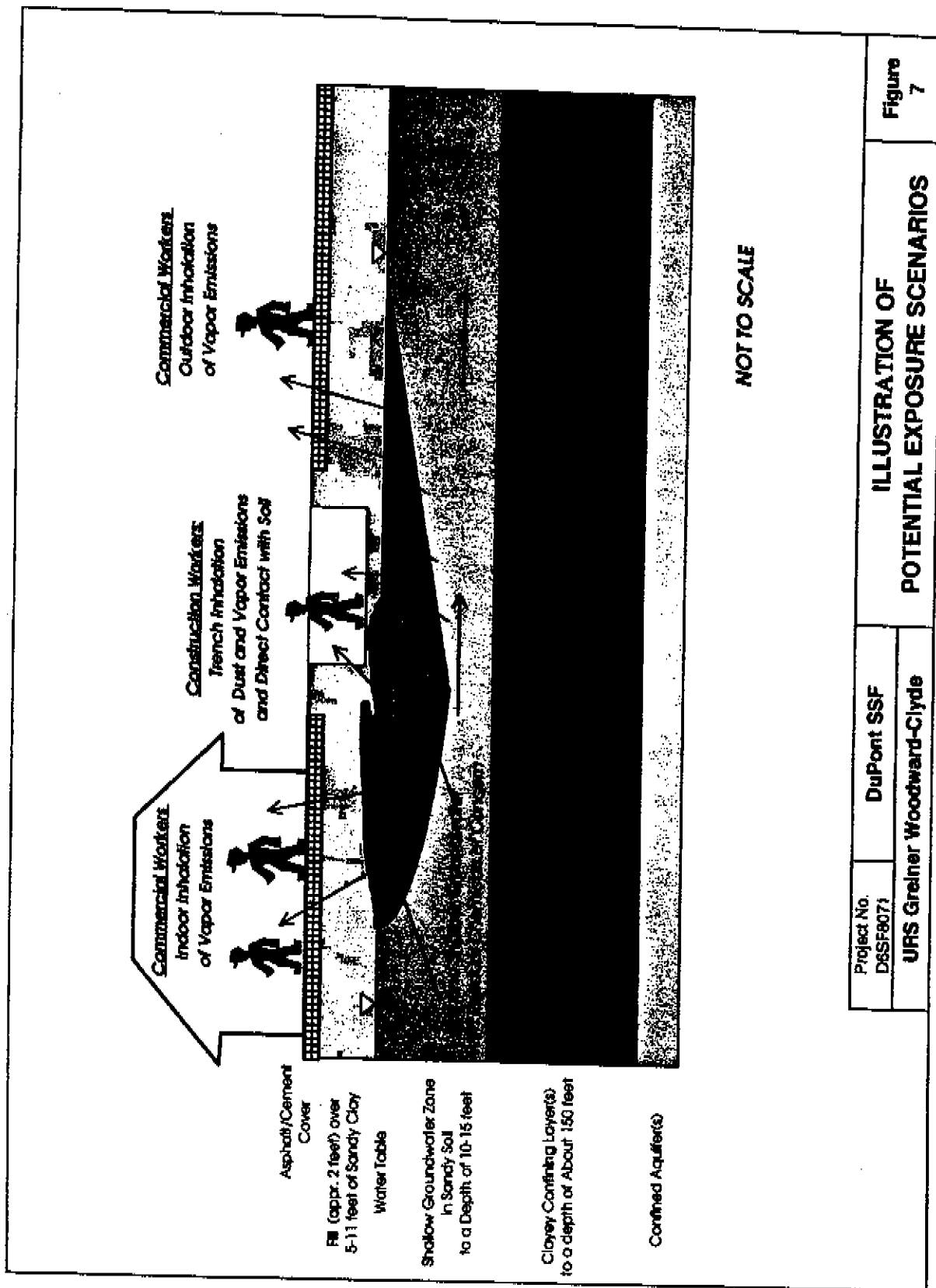
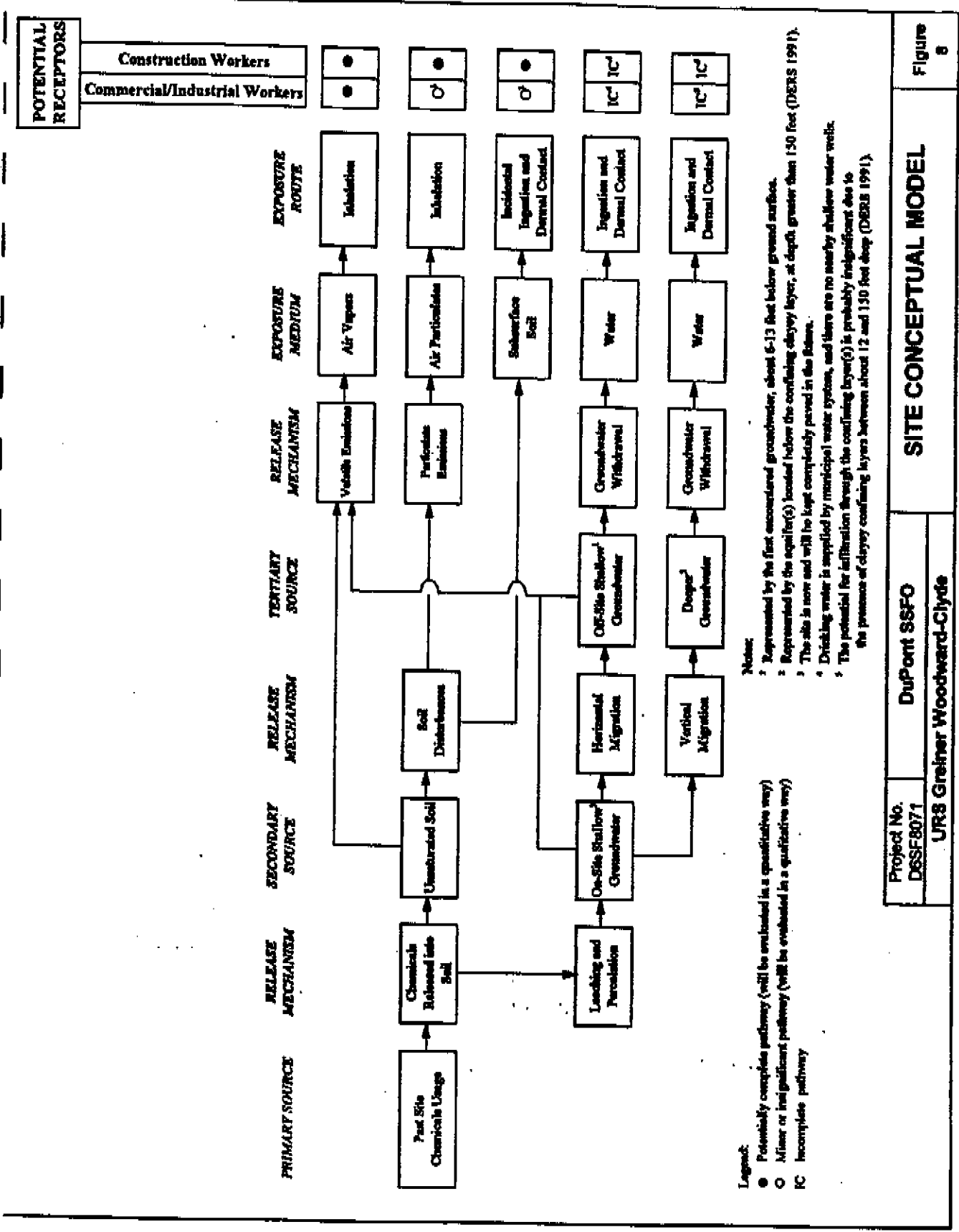


Fig-7 - SSFO



Appendix A
Risk-Based Evaluation And Development Of Tier 2 SSTIs

Appendix A

Risk-Based Evaluation And Development Of Tier 2 SSTLs

INTRODUCTION

As mentioned in Section 3.5, Condition Five requires that the site does not pose significant risk to human health. This condition was addressed by performing a risk-based evaluation according to the ASTM RBCA guidance (ASTM 1995). The RBCA methodology is a consistent and comprehensive approach to risk-based remediation of site contamination based on the protection of human health and environmental resources (e.g., groundwater quality). RBCA is also a risk management tool that may be used to support the selection of appropriate remedial measures. The RBCA methodology evaluates sites according to a tiered approach of increased site-specificity and released conservatism. Tier 1 is applied to initially classify the site, and screen for chemicals and areas of concern using non-site-specific risk-based screening levels (RBSLs). If necessary, risk-based site-specific target levels (SSTLs) are developed using Tier 2.

Concentrations of chemicals in soil and groundwater are compared to the SSTLs to evaluate if there is potential for significant risk to human health. The SSTLs represent a conservative starting point for development of cleanup goals, which are the result of risk management decisions. According to the NCP (USEPA 1990) these decisions are not solely based on protection of human health and the environment, but also on other remedial action criteria such as feasibility, cost effectiveness, public acceptability, etc., as explained in more detail at the end of this appendix.

The next sections provide a brief description of the ASTM RBCA methodology, and present the Risk-Based Evaluation consisting of the Tier 1 screening, the site conceptual model, the development of Tier 2 SSTLs, and the results of the comparison of site conditions to SSTLs.

DESCRIPTION OF THE ASTM RBCA TIER 1 AND TIER 2 PROCESS

The scope of RBCA Tier 1 is to classify the site in terms of urgency of need for initial corrective action, based on (1) historical information, (2) visual inspection, and (3) available site assessment data. Specifically, Tier 1 consists of the following:

- Identification of site-related contaminant sources, potential environmental impacts, potential transport pathways, and potentially impacted receptors.
- Comparison of site-related contaminant concentrations with conservative corrective action goals based on a list of non-site-specific risk-based screening levels (RBSLs) and other appropriate standards.

Tier 1 RBSLs are based on default exposure factors and generic site characteristics. Since the exposure and site parameters are not site-specific, the RBSLs incorporate a great amount of conservatism, and therefore are quite stringent. According to the RBCA guidance, if chemical concentrations detected in soil and groundwater at the site exceed the Tier 1 RBSLs, after the initial RBCA Tier 1 screening, the site should be evaluated and classified according to Tier 2.

In Tier 2, risk-based SSTLs for the chemicals and exposure scenarios of concern are developed based on more realistic site-specific input parameters, as appropriate. Comparison of site chemical concentrations to the SSTLs allows risk managers to evaluate whether the site needs additional consideration in terms of investigation/remediation.

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Risk-Based Evaluation And Development Of Tier 2 SSTLs

RISK-BASED EVALUATION

This section presents assumptions, methodology, and results of the human health risk-based evaluation (RBE) performed for the site. The purpose of the RBE was to evaluate if the concentrations and distribution of chemicals detected in soil and groundwater at the site warrant further consideration based on protection of human health in terms of additional characterization and/or remedial action. The RBE was performed in three tasks:

- 1) Tier 1 screening evaluation of the analytical results of the soil and groundwater investigation described in Section 2.0 above,
- 2) Development of Tier 2 risk-based site-specific target levels (SSTLs) representing soil and groundwater concentrations that are protective of human health and the environment based on the planned future industrial use of the site, and
- 3) Evaluation of site conditions based on a comparison of representative soil and groundwater concentrations to the SSTLs.

The following sections provide a description of the approach and results of the above-mentioned tasks. Discussions about the use of SSTLs in remedial decisions and the uncertainties and limitations of the risk evaluation are provided at the end of this appendix.

Tier 1 Screening of Soil and Groundwater Results

The screening evaluation of the analytical results of the site investigation and laboratory analyses presented in Section 2 of this report involved comparing the maximum detected soil and groundwater concentrations to published non-site-specific conservative screening criteria. Chemicals that did not exceed the screening criteria were eliminated from further consideration, as recommended in USEPA (1998). On the other end, exceedance of criteria indicated that the chemical needed to be evaluated based on site-specific conditions as described in the next subsections. This focuses on chemicals and related areas of highest potential concern in relation to protection of human health and the environment.

For soil, the maximum detected concentration was compared to the Region 9 Industrial Soil PRGs (USEPA 1998). The PRGs are soil concentrations corresponding to a cancer risk of 1×10^{-6} (one-in-a-million) or to a unit (1.0) non-cancer hazard quotient for a default conservative industrial exposure scenario. The industrial scenario was selected based on the planned future use of the site as a commercial/industrial facility.

For groundwater, the maximum detected concentration was compared to the MCL (DTSC 1994), the AL (DTSC 1994), or the Region 9 Tap Water PRGs (USEPA 1998), in order of priority. The MCL and AL are state and/or federal drinking water standards. The Tap Water PRGs are drinking water concentrations corresponding to a cancer risk of 1×10^{-6} (one-in-a-million) or to a unit (1.0) non-cancer hazard quotient for a commercial exposure scenario. The screening used the drinking water standards due to the lack of groundwater criteria for uses other than potable. This was done only to focus on the most important chemicals, and does not imply that the shallow groundwater should be considered a viable source of drinking water. The next subsections address the potential uses of the shallow groundwater, and the development of appropriate site-

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specific groundwater criteria that are protective of human health and the environment for the exposure scenarios corresponding to those uses.

Table 3 presents the comparison of the maximum detected soil concentrations to the Region 9 Industrial Soil PRGs (USEPA 1998). As shown in Table 3, benzene was not detected in soil above the reporting limit. The only VOC exceeding the PRG was xylene (maximum detection of 490 mg/kg exceeds the PRG of 210 mg/kg for industrial/commercial exposure scenario). The only semi-volatile exceeding the PRG was benzo(a)pyrene (maximum detection of 0.5 mg/kg slightly exceeds the PRG of 0.359 mg/kg). The only metals exceeding the PRG were arsenic and lead. Arsenic was reported at 194 mg/kg, and lead was reported at 4,200 mg/kg at sample location S1, collected at the bottom of the ballast rock at the rail spur. The PRGs for arsenic and lead are 3 mg/kg and 1,000 mg/kg, respectively.

Table 4 presents the comparison of the maximum detected groundwater concentration to water quality criteria (WQC) represented by the MCL (DTSC 1994), the AL (DTSC 1994), or the Region 9 Tap Water PRGs (USEPA 1998), in order of priority. Benzene was reported at 0.4 mg/l, exceeding the California MCL of 0.001 mg/l. A total of eight VOCs were detected in groundwater, and all of them exceeded the respective WQC, with the exception of 4-methyl-2-pentanone (no WQC was found for this compound). For the semivolatiles, di-n-butylphthalate slightly exceeded the Tap Water PRG. The concentrations of metals in groundwater were below WQC except for arsenic, which was reported at 0.113 mg/l, exceeding the MCL of 0.05 mg/l.

In conclusion, the chemicals in tables 3 and 4 with maximum concentration exceeding the screening criteria were retained for further consideration, as recommended in USEPA (1998). These analytes include:

- xylene, benzo(a)pyrene, arsenic, and lead in soil, and
- benzene, toluene, ethylbenzene, xylene, acetone, 2-butanone, 1,2-dichloroethane, di-n-butylphthalate, and arsenic in groundwater.

Exceedance of criteria indicates that the analyte needs to be evaluated based on site-specific conditions as described in the next subsections. This focuses the risk-based evaluation on the analyte and related areas of highest potential concern in relation to protection of human health and the environment.

Development of Tier 2 SSTLs

This section describes the development of risk-based site-specific target levels (SSTLs) representing soil and groundwater concentrations that are protective of human health and the environment based on the planned future industrial use of the site. The basis for the development of SSTLs is the site conceptual model described in Section A.3.3. Section A.3.4 discusses the target acceptable risk levels used in the Tier 2 evaluations. The assumptions and methodology used to calculate the SSTLs are presented in Section A.3.5. A discussion on how the SSTLs should be used to assist in remedial decisions is in Section 3.2.4. The SSTLs are used in the evaluation of site conditions presented in Section 3.3.

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Risk-Based Evaluation And Development Of Tier 2 SSTLs

Site Conceptual Model

The site conceptual model (SCM) describes plausible chemical migration pathways and exposure routes from the sources of chemicals at the site to the receptor populations that may be potentially exposed to such chemicals. The SCM is used to assist in evaluating which potential exposure scenarios are relevant for the site. The attached Figures 7 and 8 provide a visual aid to understand the SCM. Figure 7 graphically illustrates the relevant potential chemical exposure scenarios for the site. Figure 8 presents the SCM in the standard USEPA flowchart format. The importance of each of the exposure routes associated with each receptor is represented in Figure 8 by a black dot for potentially significant (complete) pathways, and by a white dot for minor or insignificant pathways (evaluated only qualitatively). In this risk-based evaluation, SSTLs are developed only for complete exposure scenarios (black dots). More detailed information about the elements of the SCM are provided in the following subsections.

As shown on Figures 7 and 8, two scenarios of potential chemical exposure were considered:

1. Future commercial/industrial worker exposure scenario.
2. Future construction worker exposure scenario. This scenario involves construction workers that may be exposed to chemicals in soil during excavation and trenching activities.
3. At the County's request, and for reference only, since the future site use is commercial/industrial, we developed a set of SSTLs for a hypothetical residential exposure scenario.

As depicted in Figure 8, relevant potential human exposure routes are by inhalation of chemicals in vapor emissions (from soil and groundwater) and air particulate emissions (soil only), and by direct contact with soil, which includes incidental ingestion of and dermal contact with soil. In our opinion, the potential for direct contact exposure to chemicals in surface water or groundwater is very low. The shallow groundwater zone does not constitute a viable source of drinking water due to the silty-clayey nature of the soil. The clayey soil also provides a barrier to vertical infiltration to deeper strata and slows down horizontal groundwater flow. No surface water bodies or water wells are on the site. We verified in Section 3.4 that no water wells are within a downgradient distance of $\frac{1}{4}$ of a mile or screened in the shallow zones. Drinking water is supplied by the municipal water system. Therefore, the water ingestion and dermal contact pathways are considered incomplete at the site.

Potential for exposure is expected to be highest for on-site workers with respect to any potential off-site receptors. Therefore, the risk-based criteria developed for on-site exposure are also protective of off-site receptors.

Target Risk Level for Tier 2

The target acceptable risk levels used in the Tier 2 development of SSTLs are based on USEPA (1989) guidance. For noncarcinogenic effects of a chemical, the target acceptable level is represented by a Hazard Quotient (HQ) of 1. The HQ is the ratio of the estimated chemical intake compared to the reference dose. When the HQs from multiple chemicals are added together, the result is called hazard index (HI). As appropriate, both terms were used in this report. The reference dose is an estimate of a daily chemical intake per unit body weight that is likely to be

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without deleterious effects during a lifetime or a portion of a lifetime (USEPA 1989). HQs (or HIs) of 1 or below indicate no adverse health effects are expected. HQs (or HIs) above 1 indicate a cause for concern for adverse effects and that further evaluation of exposure conditions and toxicity is warranted in determining the need for remedial action.

For carcinogenic effects of chemicals, potential cancer risk is described as a probability of an increased risk of cancer above the normal rate. For example, an "incremental cancer risk" of 1 in 1 million (1 in 1,000,000) means that one's chances of getting cancer has increased by 0.000001. This increase is insignificant, considering that the normal rate of cancer from all causes in the United States is about 3 in 10 (0.3). Cancer risk is calculated by multiplying the estimated intake to a cancer slope factor expressed in terms of risk per mg/kg-day. Cancer slope factors are upper-bound estimates of the dose-carcinogenic response relationships observed in studies, usually in laboratory animals.

In a letter dated December 24, 1998, Ms. Rouan specified that the target risk should be one-in-a-million, therefore the SSTLs were based on the County-specified target risk. However, for consistency with the target risk levels applied to the classification of numerous Bay Area sites (e.g., the San Francisco International Airport in San Mateo County), as a reference in support of risk management decisions, we present in the report an additional set of SSTLs based on one-in-one-hundred-thousands (1×10^{-5}) target risk. This target cancer risk level is within the target range of 1×10^{-6} to 1×10^{-4} described as acceptable by the USEPA in the NCP (USEPA 1990). USEPA guidance states that when the noncancer hazard index does not exceed an index of 1 and the estimated cancer risk does not exceed 1×10^{-4} , remediation is generally not warranted for protection of human health (USEPA 1990).

Calculations of Tier 2 SSTLs

This section describes the assumptions and methodology used to calculate the Tier 2 risk-based SSTLs for the analytes that did not pass the Tier 1 screening. These analytes are called "chemicals of (potential) concern" (COCs). The SSTLs are defined as soil and groundwater concentrations of individual chemicals that correspond to 1×10^{-5} (1 in 100,000) or 1×10^{-6} (1 in a million) target risk level for carcinogens or a unit (1.0) target hazard quotient for noncarcinogens, for the receptor exposure scenarios being considered. For chemicals that have both cancer and noncancer effects, the SSTL is selected as the lower of the risk-based concentrations (RBCs) corresponding to the specified target cancer risk and the unit hazard quotient, respectively.

The calculation spreadsheets of the SSTLs are provided at the end of this appendix. Detailed calculations of indoor exposure SSTLs for benzene are also included as an example.

Exposure Assumptions

Soil and shallow groundwater SSTLs for the commercial and the residential exposure scenarios were developed based on the DTSC (1992, 1994), USEPA (1989, 1995) and ASTM (1995) RBCA recommendations on exposure models and input parameters. Standard USEPA exposure factors (such as inhalation rates, ingestion rates, exposure duration, and exposure frequency) and toxicity factors (such as carcinogenic slope factors and reference doses) were used to estimate chemical intake via inhalation, soil ingestion, and dermal contact by workers (USEPA 1989,

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1998). These factors are considered appropriate for a conservative estimate of magnitude of exposure. Up-to-date USEPA toxicity factors (such as carcinogenic slope factors and reference doses) were used to estimate potential cancer risk and hazard index due to exposure via inhalation, soil ingestion, and dermal contact with soil (USEPA 1989, 1998a). In conclusion, the SSTLs were developed based on the following exposure assumptions:

- Soil and shallow groundwater SSTLs were developed for a commercial and a construction exposure scenario, since the present and probable future land use for the site is commercial /industrial.
- A residential scenario was also considered (for reference only).
- It is conservatively assumed that commercial workers may spend a total of 25 years, 50 weeks per year, 8 hours per day at the site.
- It is conservatively assumed that construction workers may spend a total of 2 months, five days per week, working 8 hours per day inside open trenches.
- It is conservatively assumed that hypothetical future residents may spend a total of 30 years (6 years as children and 24 years as adults), 350 days per year, 24 hours per day at the site.
- The exposure pathway of concern for the commercial and residential exposure scenarios is inhalation of vapor emissions from soil and groundwater into ambient air. It is assumed that asphalt or concrete pavement or buildings will cover the soil. The same applies to the hypothetical residential scenario.
- The exposure pathway of concern for the construction exposure scenario is inhalation of vapor emissions from soil and groundwater, inhalation of particulate emissions from soil into ambient air, and direct contact with soil (incidental ingestion and dermal absorption). It is assumed that the soil will not be covered during construction/excavation activities.
- For the commercial scenario, the indoor air exchange rate and the areal fraction of cracks in the soil cover are the only relatively important parameters (in relation to the SSTLs) that were modified with respect to RBCA Tier 1 to better represent probable indoor exposure conditions in the new site development.
- The indoor air exchange rate for residential exposure was changed from the Tier 1 rate of about one-half volume exchange per hour to a rate of one exchange per hour, corresponding to the average for natural ventilation (Walsh 1984), to represent an average exchange rate in residential dwellings without forced ventilation.
- The indoor air exchange rate for commercial exposure was changed from the Tier 1 rate of about one volume exchange per hour, corresponding to the average for natural ventilation (Walsh 1984) to a rate of five exchanges per hour, to represent an average exchange rate due to forced ventilation in commercial buildings.
- The areal fraction of cracks in the soil cover was changed from the Tier 1 value of one percent, corresponding to a pavement in bad conditions and with large openings. e.g., an opening of 9 square feet in the floor of a room of 900 square feet, to one-tenth of a percent, representing a fair condition pavement in commercial buildings.

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- For the construction scenario the ASTM RBCA (1995) does not provide default exposure parameters. It was assumed that construction workers may spend a total of 2 months, five days per week, working 7 hours per day outdoors and one hour per day inside open trenches, with an air exchange rate in the open trenches of ten volume exchanges per hour, and a respirable particulate (PM_{10}) emission rate corresponding to a PM_{10} concentration of 0.05 mg/m^3 .
- Subsurface physical parameters such as thickness of the vadose zone and depth to groundwater have been modified based on field observations, as appropriate.

Tables 5 and 6 present the exposure parameters for commercial and construction scenario, respectively. Table 7 presents the exposure parameters for the reference residential scenario. The chemical-specific toxicity parameters are provided in Table 8. Chemical-specific fate and transport parameters are in Table 9.

In general, conservative (Tier 1) non-site-specific values were used for most of the input parameters, with the following site-specific exceptions.

Site-Specific Assumptions for Commercial Exposure Scenario

For the commercial/industrial exposure scenario the following parameters affecting exposure to site chemicals were selected to reflect relevant site-specific conditions based on field measurements or on professional judgment as follows:

- Enclosed space air exchange rate = five volumes per hour
- Depth to groundwater = 2.1 m (about 7 feet)
- Depth to subsurface soil sources = 1 m
- Areal fraction of cracks in concrete pavement = $10 \text{ cm}^2/\text{m}^2$

Enclosed space air exchange rate of five per hour represents the average ventilation of industrial buildings with air conditioning (typically ranging from 1 to 10 exchanges per hour). Depth to groundwater and depth to subsurface soil sources are based on field observations. The areal fraction of cracks and openings in the concrete pavement was set at $10 \text{ cm}^2/\text{m}^2$ to represent a good condition pavement slab.

The values of other input parameters used to calculate the SSTLs were Cal/EPA DTSC, USEPA, and ASTM RBCA Tier 1 default values. A summary of the parameter values used in calculating the SSTLs is in Tables 5 through 8.

Site-Specific Assumptions for Construction Exposure Scenario

For the construction exposure scenario, the following parameters affecting exposure to site chemicals were selected to reflect relevant site-specific conditions based on Cal/EPA requirements, field measurements or on professional judgment as follows:

- Exposure duration = two months

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- Exposure time and frequency = 1 hour per working day inside trenches, 7 hours working outdoor
- Enclosed space air exchange rate = ten volumes per hour in open trenches
- Depth to groundwater = 0.05 m (assumes bottom of trench at the water table)
- Depth to subsurface soil sources = 0.01 m (assumes bottom of trench in contact with source)
- Areal fraction of cracks in concrete pavement = $0.999 \text{ m}^2/\text{m}^2$ (no soil cover in trenches)
- Particulate emission rate = $1.5 \times 10^{-9} \text{ g}/\text{cm}^2\text{-sec}$
- No barriers to vapor emissions in trenches

The particulate emission rate of $1.5 \times 10^{-9} \text{ g}/\text{cm}^2\text{-sec}$ corresponds to a respirable particulate matter less than 10 microns in diameter (PM10) concentration of $50 \text{ }\mu\text{g}/\text{m}^3$, the maximum annual average ambient air concentration allowed by the USEPA Clean Air Act. This value is considered a reasonable maximum average concentration over a two-month exposure duration at the site.

Site-Specific Assumptions for Residential Exposure Scenario

For the residential exposure scenario, the following parameters affecting exposure to site chemicals were selected to reflect relevant site-specific conditions based on Cal/EPA requirements, field measurements or on professional judgment as follows:

- Exposure duration = 24 years as adults and 6 years as children (30 years total)
- Exposure time and frequency = 50 weeks per year, 24 hours per day indoor
- Enclosed space air exchange rate = one volume per hour
- Depth to groundwater = 2.1 m (about 7 feet)
- Depth to subsurface soil sources = 1 m
- Areal fraction of cracks in concrete pavement = $10 \text{ cm}^2/\text{m}^2$

The exposure duration of 24 years as adults and 6 years as children was assumed according to the DTSC and USEPA guidance. Note that the ASTM RBCA guidance does not consider children in residential exposure scenarios. The enclosed space air exchange rate of one volume exchange of fresh air per hour represents the average natural ventilation rate in residential homes (Walsh 1984). Depth to groundwater and depth to subsurface soil sources are based on field observations. The areal fraction of cracks and openings in the concrete pavement was set at $10 \text{ cm}^2/\text{m}^2$ to represent a good condition pavement slab.

Use of SSTLs in Remedial Decisions

The SSTLs may serve as a conservative starting point for the development of preliminary remediation goals for the site; that is, they may be used as a guide for risk management planning. However, they are not necessarily final cleanup goals, because they are based on conservative models and assumptions that may overpredict risk, and they do not consider other factors that

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necessarily affect risk management decisions. As stated in the NCP, these factors include overall protection of human health and the environment, technical implementability, short- and long-term effectiveness, cost, reliability, and public acceptability (USEPA 1990c, 1991).

Comparison of Site Conditions to SSTLs

Tables 10 and 11 present the Tier 2 comparisons of site representative soil and groundwater concentrations with the most stringent of the SSTLs calculated for the commercial and the construction worker exposure scenarios. For volatile chemicals, the SSTLs used for the comparisons correspond to indoor exposure of commercial workers and trench exposure of construction workers. For the non-volatile di-n-butylphthalate and lead, the industrial soil and the tap water PRGs or the MCLs were used as SSTLs.

For arsenic in soil, the concentration of 22 mg/kg was used as SSTL. This concentration corresponds to the USEPA (1998) Region 9 non-cancer endpoint PRG for a residential scenario. According to the USEPA (1998), when naturally occurring arsenic soil concentrations exceed the risk-based PRG set at a one-in-a-million cancer risk, the non-cancer residential PRG of 22 mg/kg is used to evaluate sites, recognizing that this value tends to be above average background concentrations yet still falls within the USEPA "permissible" risk range of 1×10^{-6} to 1×10^{-4} . In addition, this 22 mg/kg threshold for arsenic in soil is consistent with the expected natural background concentration upper ranges in Northern California soil. This consideration is based on the results of background studies (Shaklette, H. T., et al., "Elemental Composition of Surficial Material in the Conterminous United States", 1971), (USGS Professional Paper "Geochemistry of Some Rocks, Soil, Plant and Vegetables in the Conterminous United States", 1975), (C. Scott, "Background Metal Concentrations in Soils in Northern Santa Clara County, California", MS Thesis, USF 1991.). These studies indicate that in Santa Clara County the arsenic mean soil concentration was found to be about 2.9 mg/kg, and the upper range of arsenic soil background concentrations in the Western U.S. is well above 150 mg/kg, with a mean of 11 mg/kg. Recently, background threshold levels of the order of 12 to 21 mg/kg were approved by Cal/EPA and other local Agencies for Bay Area sites such as the Hamilton Army Airfield in Novato. The FMC site in San Jose, and the San Francisco International Airport in San Mateo. Based on the above considerations, it is concluded that the background threshold corresponding to the non-cancer endpoint PRG of 22 mg/kg is appropriate to represent the SSTL for arsenic in site soil.

The site representative concentrations for the comparisons were conservatively based on the 95 percent upper confidence level (UCL) on the mean (USEPA 1992). The UCL calculations are presented in Appendix F.

The comparisons involve the chemicals that failed the Tier 1 screening presented in Tables 3 and 4. If the site-representative concentration of a chemical does not exceed its SSTL, no significant health threat is posed by that chemical. If the concentration does exceed the SSTL, there is potential for adverse health effects. Whether an actual health threat exists will depend upon the actual chemical concentrations to which people are exposed and the magnitude of their exposure.

Both the maximum detected and the UCL concentrations are used as the exposure point concentrations for the Tier 2 comparison. The use of the UCL concentration is consistent with the USEPA (1992) guidance for estimating the source term in exposure assessment.

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At the County's request, the target risk of one-in-a-million was used for the comparisons. However, for consistency with the target risk levels applied to the classification of numerous Bay Area sites (e.g., the San Francisco International Airport in San Mateo County), as a reference in support of risk management decisions, we present in the Tier 2 tables an additional set of SSTLs based on one-in-one-hundred-thousands target risk.

Table 10 Tier 2 comparisons for soil indicate that:

- Site-averaged detected soil concentrations never exceeded SSTLs
- Xylene maximum detected concentrations do not exceed SSTL. However, the relatively high detections indicate that free product hydrocarbons may constitute a chemical source at the Tank Farm area.
- Arsenic and lead maximum detections exceed the respective SSTLs at location S1 and at Boring 22.

Based on the above considerations we conclude that if the areas where relatively high arsenic and lead concentrations are remediated, no health threat is posed by residual chemicals detected in soil under the exposure conditions evaluated (commercial workers and construction workers).

For groundwater, Table 11 Tier 2 comparisons indicate that:

- Site-averaged detected groundwater concentrations never exceeded SSTLs
- Di-n-butylphthalate maximum detected concentration of 5.1 mg/l marginally exceeds tap water PRG of 3.7 mg/l. Note that the tap water PRG is based on the unlikely assumption of shallow groundwater use as a potable water source. The PRG was used for lack of applicable risk-based criteria, and it is over-conservative.
- Arsenic maximum detected concentration of 0.113 mg/l exceeds the MCL of 0.05 mg/l at Boring 22. As noted above, the MCL is based on the unlikely assumption of shallow groundwater use as a potable water source. The MCL was used for lack of applicable risk-based criteria, and it is over-conservative.

Based on the above considerations we conclude that the exceedances of SSTLs in groundwater are marginal and not relevant to the exposure scenarios of concern. Therefore, no health threat is posed by residual chemicals detected in shallow groundwater under the exposure conditions evaluated (commercial workers and construction workers).

UNCERTAINTY AND VARIABILITY IN RISK ASSESSMENT

The quantitative methods and procedures described in this document for evaluating potential exposure and risk are based on a number of simplifying assumptions related to the characterization of the contaminant sources and of the subsurface environment. The exposure models are based on descriptions of relevant physical/chemical phenomena. Any mechanisms that are neglected, such as neglecting attenuation due to natural biodegradation, result in predictions of exposure and risk that are conservative relative to those likely to occur. In other words, the models are biased towards predicting exposure concentrations in excess of those likely to occur (ASTM 1995). Uncertainty and variability affect the input parameters of all of the exposure and fate and transport models. Conservative values of those input parameters are

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selected to deal with this uncertainty and variability. Since the exposure models are multiplicative, conservatism is compounded in the calculations. For this reason, the modeling results in this study are expected to overestimate exposure and risk, rather than underestimate the actual risk posed by the site.

The degree of conservatism in this assessment is illustrated by the following: the target levels for commercial workers proposed in this study are estimated by the models to be protective of a receptor assumed to work at the site for 25 years, 250 days per year, 8 hours per day, and to inhale volatile emissions from soil and groundwater generated by a continuous (i.e., non-degrading, infinite mass) source for the entire exposure duration. The models estimate that if the average source concentrations do not exceed SSTLs, such a receptor would be subject to an excess cancer risk of less than 1 in 100,000 as a consequence of chemical exposure.

Calculation Tables For Commercial Exposure Scenarios

TABLE. COMMERCIAL EXPOSURE FACTORS AND ENVIRONMENTAL PARAMETERS

PARAMETER	Units	Value	Reference
EXPOSURE PARAMETERS			
Averaging Time for Carcinogens	yr	70	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Averaging Time for Noncarcinogens	yr	25	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Body Weight Adult	kg	70	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Exposure Duration Adult	yr	25	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Exposure Frequency	days/yr	250	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Soil Ingestion Rate Adult	mg/day	50	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Daily Indoor Inhalation Rate Adult	m ³ /day	20	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Daily Outdoor Inhalation Rate Adult	m ³ /day	20	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Daily Water Ingestion Rate Adult	L/day	1	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Soil to Skin Adherence Factor	mg/cm ²	0.5	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Oral Relative Absorption Factor	—	1	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Skin Surface Area Adult	cm ²	3,160	Cal/EPA (1992, 1994) - ASTM Default Value (ASTM 1995)
Target Hazard Quotient for Individual Constituents	—	1	NCP's hazard threshold (USEPA 1990)
Target Excess Individual Lifetime Cancer Risk	—	1.0E-6	Lowest order of magnitude of NCP's acceptable risk range (USEPA 1990)
ENVIRONMENTAL FATE AND TRANSPORT PARAMETERS			
Lower depth of surficial soil zone	cm	100	ASTM Default Value (ASTM 1995)
Backsided space air exchange rate	1/sec	0.0014	five volume exchanges per hour - forced ventilation
Fraction of organic carbon in soil	g-C/g-soil	0.01	ASTM Default Value (ASTM 1995)
Thickness of capillary fringe	cm	5	ASTM Default Value (ASTM 1995)
Thickness of vadose zone	cm	265	about 7 feet, based on field observations
Infiltration rate of water through soil	cm/yr	30	ASTM Default Value (ASTM 1995)
Backsided space volume/infiltration area	cm	300	ASTM Default Value (ASTM 1995)
Backsided space foundation/wall thickness	cm	15	ASTM Default Value (ASTM 1995)
Depth to groundwater	cm	310	about 7 feet, based on field observations
Depth to subsurface soil neurons	cm	100	ASTM Default Value (ASTM 1995)
Particulate emission rate	g/cm ² -s	6.9E-14	ASTM Default Value (ASTM 1995)
Wind speed above ground surface in ambient mixing	cm/s	225	ASTM Default Value (ASTM 1995)
Groundwater Darcy velocity	cm/yr	2500	ASTM Default Value (ASTM 1995)
Width of source area parallel to wind or gw flow	cm	1500	ASTM Default Value (ASTM 1995)
Ambient air mixing zone height	cm	200	ASTM Default Value (ASTM 1995)
Groundwater mixing zone height	cm	200	ASTM Default Value (ASTM 1995)
Area fraction of cracks in foundation/walls	cm ² /cm ²	0.001	good condition pavement
Volumetric air content in capillary fringe soils	cc/cc	0.038	ASTM Default Value (ASTM 1995)
Volumetric air content in found./wall cracks	cc/cc	0.36	ASTM Default Value (ASTM 1995)
Volumetric air content in vadose zone soils	cc/cc	0.36	ASTM Default Value (ASTM 1995)
Total soil porosity	cc/cc-soil	0.38	ASTM Default Value (ASTM 1995)
Volumetric water content in capillary fringe soils	cc/cc	0.343	ASTM Default Value (ASTM 1995)
Volumetric water content in found./wall cracks	cc/cc	0.13	ASTM Default Value (ASTM 1995)
Volumetric water content in vadose zone soils	cc/cc	0.13	ASTM Default Value (ASTM 1995)
Soil bulk density	g/cc	1.7	ASTM Default Value (ASTM 1995)
Averaging time for vapor flux	sec	7.88E+8	ASTM Default Value (ASTM 1995)

References:

- Cal/EPA, 1992, Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities. OSA, July.
 Cal/EPA, 1994, Preliminary Exposure Assessment Guidance Manual. DTSC, January.
 ASTM, 1995, Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites. E 1739-95, November.
 USEPA, 1990, 40 CFR Part 300, National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Final Rule, 55(46): 8640-8669, March 8.

TABLE. EXAMPLE CALCULATIONS OF INDOOR SOIL SSTLs

Chemical: Benzene (Based on Carcinogenic Risk)
Exposure Pathway: Indoor inhalation of vapors from subsurface soil
Exposure Scenario: Commercial

Based on ASTM RBCA Guidance E 1739 - 95, p. 23, formula 1.

$$\text{SSTLs [mg/kg]} = \text{SSTLair } [\mu\text{g/m}^3] \times 10^{-3} [\text{mg}/\mu\text{g}] / \text{VFesp}$$

$$\text{SSTLair } [\mu\text{g/m}^3] = \text{TR} \times \text{AT} \times 365 [\text{days/year}] \times 1,000 [\mu\text{g}/\text{mg}] \times [\text{SFI} \times \text{EF} \times (\text{ED} \times \text{IRair}_{\text{indoor}} / \text{BW})]$$

$$\text{SSTLair } [\mu\text{g/m}^3] = 1.0\text{E-}6 \times 70 \times 365 \times 1,000 / [1.10\text{E-}1 \times 250 \times (25 \times 20 / 70)]$$

$$\text{SSTLair } [\mu\text{g/m}^3] = 1.30\text{E-}1$$

$$\text{VFesp} = \text{H}' \rho_a \text{D}_{\text{eff},a} 1,000 [\text{cm}^3\text{-kg}/\text{m}^3\text{-g}] / [\text{L}_s \text{ER} \text{L}_s (\theta_{\text{ws}} + \text{k}_a \rho_a + \text{H}' \theta_{\text{sa}})] \times \\ / \{ 1 + \text{D}_{\text{eff},a} / (\text{L}_s \text{ER} \text{L}_s) + \text{D}_{\text{eff},a} \text{L}_{\text{crack}} / (\text{D}_{\text{eff,crack}} \text{L}_s \eta) \}$$

$$\text{D}_{\text{eff},a} [\text{cm}^2/\text{s}] = \text{D}_{\text{air}} \theta_{\text{sa}}^{3.33} / \theta_{\text{T}}^2 + \text{D}_{\text{water}} \theta_{\text{ws}}^{3.33} / (\text{H}' \theta_{\text{T}}^2)$$

$$\text{D}_{\text{eff},a} [\text{cm}^2/\text{s}] = 0.093 \times (0.26)^{3.33} / (0.38)^2 + 1.10\text{E-}5 \times (0.12)^{3.33} / (2.26\text{E-}1 \times (0.38)^2)$$

$$\text{D}_{\text{eff},a} [\text{cm}^2/\text{s}] = 7.26\text{E-}3$$

$$\text{D}_{\text{eff,crack}} [\text{cm}^2/\text{s}] = \text{D}_{\text{air}} \theta_{\text{a,crack}}^{3.33} / \theta_{\text{T}}^2 + \text{D}_{\text{water}} \theta_{\text{w,crack}}^{3.33} / (\text{H}' \theta_{\text{T}}^2)$$

$$\text{D}_{\text{eff,crack}} [\text{cm}^2/\text{s}] = 0.093 \times (0.26)^{3.33} / (0.38)^2 + 1.10\text{E-}5 \times (0.12)^{3.33} / (2.26\text{E-}1 \times (0.38)^2)$$

$$\text{D}_{\text{eff,crack}} [\text{cm}^2/\text{s}] = 7.26\text{E-}3$$

$$\text{VFesp} = 2.26\text{E-}1 \times 1.7 \times 7.26\text{E-}3 \times 1000 / [100 \times 0.0014 \times 300 \times (0.12 + 0.01 \times 65 \times 1.7 + 2.26\text{E-}1 \times 0.26)] \times \\ / (1 + 7.26\text{E-}3 / (100 \times 0.0014 \times 300) + 7.26\text{E-}3 \times 15 / (7.26\text{E-}3 \times 100 \times 0.001))$$

$$\text{VFesp} = 3.42\text{E-}4$$

$$\text{SSTLs [mg/kg]} = 1.30\text{E-}1 \times 1.0\text{E-}3 / 3.42\text{E-}4$$

$$\text{SSTLs [mg/kg]} = 3.81\text{E-}1$$

TABLE. EXAMPLE CALCULATIONS OF INDOOR GROUNDWATER SSTLs

Chemical: Benzene (Based on Carcinogenic Risk)
Exposure Pathway: Indoor inhalation of vapors from shallow groundwater
Exposure Scenario: Commercial

Based on ASTM RBCA Guidance E 1739 - 95, p. 23, formula 1.

$$SSTLw [mg/L] = SSTLair [\mu g/m^3] \times 10^{-3} [mg/\mu g] / VFwesp$$

$$SSTLair [\mu g/m^3] = TR \times BW \times AT \times 365 [days/year] \times 1,000 [\mu g/mg] \times / (SFI \times EF \times ED \times I_{Rair-indoor})$$

$$SSTLair [\mu g/m^3] = 1.0E-6 \times 70 \times 365 \times 1,000 / [1.10E-1 \times 250 \times (25 \times 20 / 70)]$$

$$SSTLair [\mu g/m^3] = 1.30E-1$$

$$VFwesp = H' D_{eff,ws} 1,000 (L/m^3) / (L_{GW} ER L_B) \times \\ / [1 + D_{eff,ws} / (L_{GW} ER L_B) + D_{eff,ws} L_{crack} / (D_{eff,crack} L_{GW} \eta)]$$

$$Deff,ws [cm^2/s] = (hcap + hv) (hcap / D_{eff,ws} + hv / D_{eff,s})^{-1}$$

$$Deff,cap [cm^2/s] = D_{air} \theta_{soil}^{1.33} / \theta_T^2 + D_{water} \theta_{water}^{1.33} / (H' \theta_T^2)$$

$$Deff,cap [cm^2/s] = 0.093 \times (0.038)^{1.33} / (0.38)^2 + 1.10E-5 \times (0.342)^{1.33} / (2.26E-1 \times (0.38)^2)$$

$$Deff,cap [cm^2/s] = 2.15E-5$$

$$Deff,s [cm^2/s] = D_{air} \theta_{soil}^{1.33} / \theta_T^2 + D_{water} \theta_{water}^{1.33} / (H' \theta_T^2)$$

$$Deff,s [cm^2/s] = 0.093 \times (0.28)^{1.33} / (0.38)^2 + 1.10E-5 \times (0.12)^{1.33} / (2.26E-1 \times (0.38)^2)$$

$$Deff,s [cm^2/s] = 7.26E-3$$

$$Deff,ws [cm^2/s] = (5 + 205) \times (5 / 2.15E-5 + 205 / 7.26E-3)^{-1}$$

$$Deff,ws [cm^2/s] = 8.05E-4$$

$$Deff,crack [cm^2/s] = D_{air} \theta_{soil}^{1.33} / \theta_T^2 + D_{water} \theta_{water}^{1.33} / (H' \theta_T^2)$$

$$Deff,crack [cm^2/s] = 0.093 \times (0.28)^{1.33} / (0.38)^2 + 1.10E-5 \times (0.12)^{1.33} / (2.26E-1 \times (0.38)^2)$$

$$Deff,crack [cm^2/s] = 7.26E-3$$

$$VFwesp = 2.26E-1 \times 8.05E-4 \times 1000 / (210 \times 0.0014 \times 300) /$$

$$[1 + 8.05E-4 / (210 \times 0.0014 \times 300) + 8.05E-4 \times 15 / (7.26E-3 \times 210 \times 0.001)]$$

$$VFwesp = 2.31E-4$$

$$SSTLw [mg/L] = 1.30E-1 \times 1.0E-3 / 2.31E-4$$

$$SSTLw [mg/L] = 5.64E-1$$